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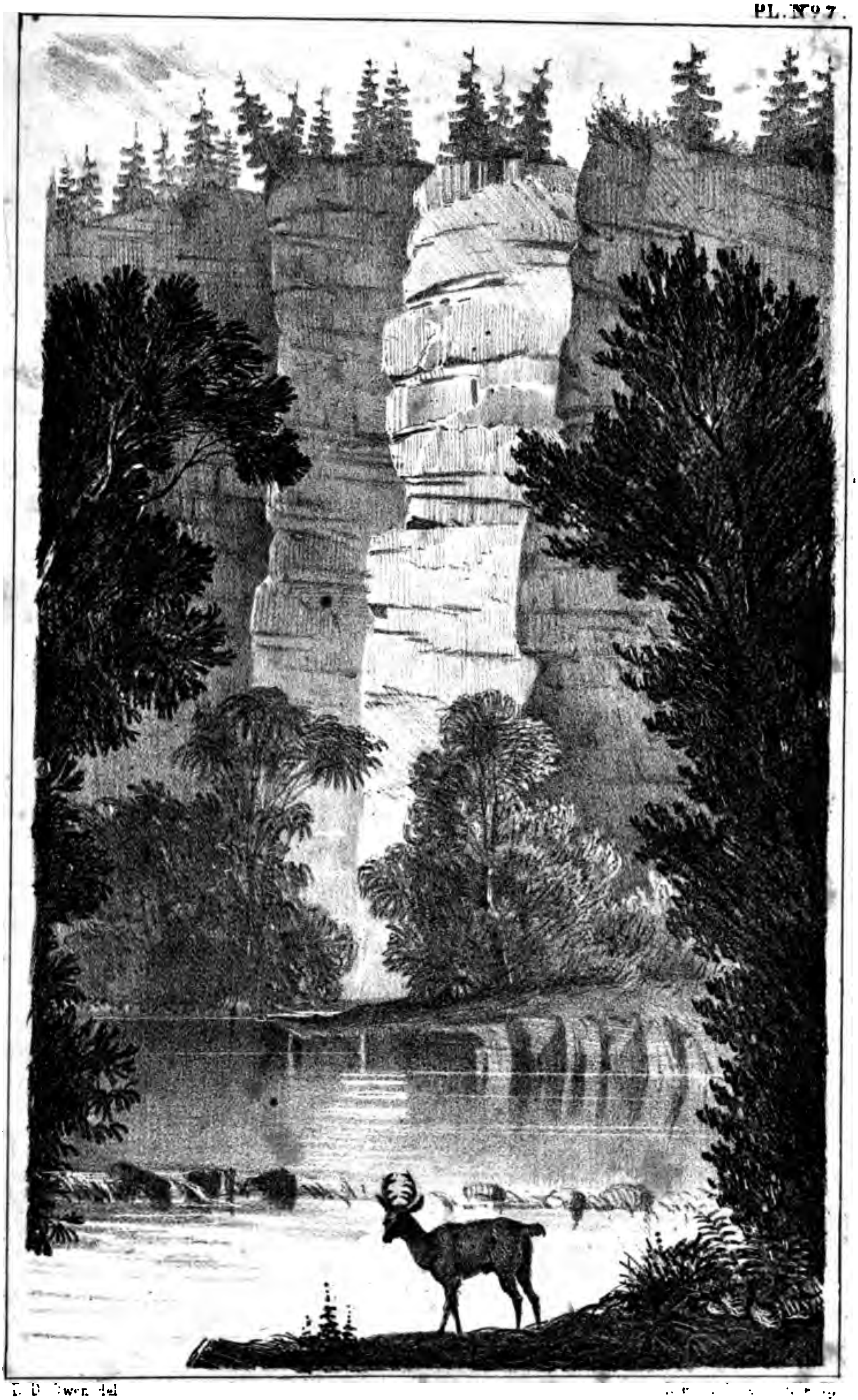

D. D. Owen del. [illegible]

CLIFFS OF CONGLOMERATE BASED ON ARCHIMEDES LIMESTONE 190 FEET HIGH.
MOUTH OF DISMAL CREEK CONFINES OF EDMONDSON AND GRAYSON COUNTIES.

# GEOLOGICAL SURVEY.

26685

# REPORT OF THE GEOLOGICAL SURVEY IN KENTUCKY,

MADE DURING THE YEARS 1854 AND 1855,

BY

## DAVID DALE OWEN.

PRINCIPAL GEOLOGIST;

ASSISTED BY

ROBERT PETER, Chemical Assistant;
SIDNEY S. LYON, Topographical Assistant.

FRANKFORT, KENTUCKY.
A. G. HODGES, STATE PRINTER.
1856.

# INTRODUCTORY LETTER.

HIS EXCELLENCY, C. S. MOREHEAD,
GOVERNOR OF KENTUCKY:

SIR:—Immediately on the receipt of my appointment by Governor Powell, bearing date 26th of April, 1854, I proceeded to procure the necessary instruments required for the Geological Survey of Kentucky, to organize the Geological Corps, and make all the arrangements required preparatory to entering upon the field duties.

On the 2d of May, 1854, Prof. Robert Peter, of Lexington, was appointed Chemical Assistant to the Survey; and on the 25th of the same month, Mr. Sidney S. Lyon, of Louisville, was appointed Topographical Assistant.

As it became necessary that I should proceed to New York and Philadelphia to procure some of the instruments, as well as a portion of the camp-equipage, it was some weeks before all the arrangements could be completed.

By the 10th of June the outfits required for Camp No. 1 were obtained, and the day following the field work was commenced, and continued until the middle of November. The Winter months were devoted to working up, in the office and laboratory, the materials collected during the Summer and Fall.

The operations of the Topographical Corps were postponed till Autumn, for the following reasons: Before a judicious direction could be given to this part of the Survey, it was necessary that a knowledge should be obtained of the *general* Geology of the country; the season of the year when the view is least obstructed by foliage and undergrowth is that most favorable for its operations; and finally, the means at my disposal, for this part of the Survey, were insufficient to keep the Corps in the field but for a limited time.

The Topographical Assistant entered upon his duties the 11th of September, but his Corps was not fully organized until November.

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Now that I contemplate the vast amount of important, practical, geological, mineralogical, chemical, and geographical facts which have been collected, and the materials that have to be plotted, arranged, systematically classified, and recorded in their appropriate places, I perceive that it will be difficult to condense them within the limits of a manuscript of reasonable length, and that it will require the closest application to complete the preparation of the Report by the 1st of

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A State stretching 400 miles, from 82° to 89° 30′ of west longitude, with an average width of more than 100 miles, lying between 36° 30′ to 39° of north latitude, and embracing 40,000 square miles, includes an amount of territory which it would be difficult even to traverse, at the ordinary rate of travel, so as to pass through all the 103 counties embraced therein, in less than a season. When we consider, then, that in order to arrive even at an approximation towards the general boundaries of the principal Geological formations, many counties have to be traversed in several directions, it will be apparent how much time is required to complete even a Geological Reconnoissance of so great an extent of country.

With all the industry which I could bring to bear I have only been able to visit sixty-three (63) counties, up to the time when it became necessary that I should commence making out the Report. In selecting these for the commencement of the work I have been chiefly guided by the tenor of my instructions, which required that I should begin with the "mineral regions." My course has been regulated, in part, however, with a view to ascertain the areas, boundaries, and succession of the Geological formations in those parts of the State where these have been least understood.

Now that I contemplate the vast amount of important, practical, geological, mineralogical, chemical, and geographical facts which have been collected, and the materials that have to be plotted, arranged, systematically classified, and recorded in their appropriate places, I perceive that it will be difficult to condense them within the limits of a manuscript of reasonable length, and that it will require the closest application to complete the preparation of the Report by the 1st of *calcareous* quaternary loams are productive and especially well adapted for the growth of silky tobacco and maize; the large amount of soluble saline ingredients which they contain, and their general fertility, compared with the proportion of silica and alumina, is, in a great measure, to be attributed to the finely comminuted condition of their ingredients.

The occurrence of the bones of the Megalonyx, extinct Elephant or Mammoth and Mastodon, in the midst of the deposits described in the preceding pages, is sufficient proof that they are cotemporaneous with the existence of these extraordinary gigantic animals. At the same time, their superficial position, incoherent character, and, more especially, the occurrence of abundant remains of *Paludina ponderosa*, *P. vivipera*, *Melania canaliculata*, *Helix fraterna*, *Planorbis bicarinata*, *Cyclas rivularis*, *Valvata tricarinata*, disseminated in the different beds, conclusively bespeaks their *recent* origin.

After this continent had fairly emerged from the ocean in which the marine tertiary beds were thrown down, there was yet an immense lapse of time intervened before the rivers assumed their present dimensions. For a long period, in the course of the principal valleys, wide expanses of fresh water stretched far and wide over the low grounds, or were confined by local barriers then existing. Into these basins of still water the fine debris, swept down from the adjacent high grounds by floods and periodical freshets, subsided, entombing, occasionally, bones of the gigantic Mammalia, which found subsistence on the neighboring dry land, and which, from death or accident, came within the range of the same transporting causes.

Partly by the gradual elevation of land, operating through a long succession of ages, from subterranean causes; partly by the wearing away of barriers, which acted like dams in holding the waters back, these expansions of fresh water drained away. The submerged sediments then gradually became part of the dry land, and subject themselves to denuding agencies, as the waters gradually contracted into their present channel, and were finally scooped out and laid bare in our river escarpments to the depth of fifty (50) to one hundred and sixty (160) feet.

Thus the materials, mixed during a renewed suspension in water, with other earths, were re-deposited at lower levels in the form of silt and river alluvium, contributing largely to the formation of our present bottom land and prairie soils and sub-soils.

Such I conceive to have been the cause, and such the circumstances and period, under which these loamy and marly sediments were produced, the materials having been derived chiefly, as already remarked, in part, from the sub-carboniferous formation, and partly also from the coal measures. Local and temporary currents, which supervened in times of extraordinary freshets and commotion of the waters during earthquakes, occasionally transported gravel, which is here and there interstratified amongst the great mass of fine sediment. These also swept in rafts of timber, which, after being water-soaked, sunk and were buried in the mud, where, excluded from the atmosphere and protected from the causes of ordinary atmospheric decomposition, they underwent that change which gives rise to the various forms of lignite, brown coal, jet, asphaltum, and other combustible principals produced under similar circumstances.

### COAL MEASURES.

Under this head are classed, not only the beds of coal of the Carboniferous era, but all the sandstones, shales, clays, ironstone, and limestone, interstratified and associated therewith, as well as the conglomerates and millstone grit.

A very large area of Kentucky is occupied by this, the most important of geological formations, in a practical point of view. There is, indeed, no State in the Union, except Kentucky, whose territory extends over a large area of *two* coal fields.

In South-western Kentucky the whole of eight (8) counties, and a part of four other counties, are embraced in the Middle coal field of the Mississippi valley, or the coal field which lies partly in Illinois, partly in Indiana, and partly in Kentucky. In Eastern Kentucky fifteen (15) counties, and a large area of five (5) more counties, are included in the Great Appalachian coal field, i. e., in the coal region occupying the western slopes of the Alleghany mountains and the Cumberland range, situated partly in Pennsylvania, Virginia, Ohio, Tennessee, and these above mentioned eastern counties of Kentucky.

Of the hundred and three (103) counties of this State, more than twenty-six (26) counties may be considered as situated in the coal measures—or over one-quarter of the whole area of the State.

The geological formations of the South-western coal field of Kentucky are better understood, at present, than its Eastern coal field, lying more remote from the Ohio river. I have spent, however, several months last Summer in a reconnoissance of a considerable portion of the Eastern coal field, and am able now to furnish important information in regard to its extent, resources, and the qualities of some of the principal beds.

The approximate boundaries of the Southern coal field, situated in Kentucky, are as follows: Commencing on the Ohio river at the mouth of Tradewater, it runs up the valley of that stream, whose course very nearly coincides with its south-western limits. From near the sources of Tradewater, in the northern part of Christian county, its southern boundary runs by the head-waters of Pond river, near the lines dividing Muhlenburg, Todd, Logan, and Butler counties, crossing Muddy river near its forks; thence through the southern part of Butler county, crossing Barren river between the mouth of Gasper river and the junction of Barren river and Green river; thence east along the divide between those rivers, through Warren and Edmonson counties, to near the mouth of Nolin creek; thence nearly north to the mouth of Dismal. Either an outlier or tongue of the coal measures appears to stretch away to the east, to the confines of Grayson and Hart counties, and even on to the waters of Roundstone; but the main boundary takes from Dismal creek a north-westerly course south of Grayson Springs, near the sources of Clay Lick and Caney creeks, towards the Falls of Rough creek; thence north by the sources of Panther creek, nearly along the line dividing Hancock and Breckinridge counties, until it strikes the Ohio river again at the Great South Bend, near the limits of the above counties.

Such are the general boundaries of this coal field, as far as at present ascertained. All the territory included between this line and the Ohio river may be regarded as belonging to the coal formation, but the line cannot be defined in all its meanders until the detailed survey shall have been carried through Hopkins, Muhlenburg, Christian, Todd, Butler, Warren, Edmonson, Grayson, Hart, Breckinridge, and Hancock, and their topography plotted accurately, as has been accomplished of Union and part of Crittenden counties.

The coal beds included in these counties naturally divide themselves into Upper and Lower Coal Measures. These are separated from each other not only by a prominent sandstone formation, but they have been cast off from continuity, immediately on the Ohio river, by an extensive uplift and dislocation of the geological formation which stretches from Gold Hill, on the Illinois side of the Ohio river, across the bed of that stream, at Shawneetown, to Bald Hill, in Union county.

The Topographical Assistant, in his detailed survey of Union county, has traced a continuation of this upheaval in a nearly east and west course through the entire county. Beyond the Valley of Cypress this disturbed belt has an increased width to the boundary of Henderson county. Beyond this point it has not yet been systematically followed; but the occurrence of disturbances, with a reversal of dip, near the confluence of Pond and Green rivers, render it probable that it can be traced completely through the coal field.

In Kentucky there is no evidence whatever that this disturbance occurred prior to the deposition of the coal measures; on the contrary it has implicated in its movements not only the sub-carboniferous limestone and millstone grit, but also the entire coal formation, which lies in conformable dip on either side of the axis. In the north-east edge of Union county, and in the bed of the Ohio river, the tilted strata, lying immediately in the line of greatest disturbance, are cast up on edge and lie in great confusion—especially where the strata seem to have partially sunk back into the chasm—and thus been much fractured, crushed, and thrown out of place, so as to convey, to limited observation, the appearance of unconformability; but it can be conclusively shown that the coal measures north and south of this disturbance were deposited in one and the same basin. For a limited space along the Ohio river, the Shawneetown fault has rent asunder the coal measures, and thrown off the upper coal measures to the north, and the lower coal measures to the south; but in the interior of Union county the upper coal measures occur on both sides of the disturbance, and, though their continuity is broken for a certain distance, the perfect identity of some of the beds on both sides of the disturbance is clearly apparent. North of this disturbance the upper coal measures prevail as high up the river as its south bend, in Daviess county; south of this disturbance, down to the mouth of Tradewater, the lower coal measures extend even to the elevated ridges of Duffis' creek.

Only a partial insight has yet been obtained of the details of the stratification of the upper coal measures, from local sections, a few *laris, Say; Cyclostoma lapidaria, Say; Physa heterostropha, Say; Lymnia elongata, Say; Planorbis bicarinata, Say; P. lens, Say; Valvata tricarinata, Say;* and fragments of Unios, with stems and limbs of trees.

Just beneath this ferruginous sand and shell bed is a blue, or rather, a dark ash-colored clay. This clay has been most remarkably hollowed out into large cavities ("pot holes"). Into these cavities ferruginous sand has been swept, apparently by eddying currents of the Ohio river.

This ferruginous sand is very irregular as to thickness, forming rather isolated deposits than one connected, continuous bed. At a higher level, (forty to fifty feet above the ordinary low water,) the fine silicious earths and marls are found, which are so universally distributed over the lower grounds in the vicinity of the Ohio, Mississippi, and Wabash rivers, even up to the height of one hundred feet and more, and which are locally characterized by several species of *Helix, Pupa armigera, Say; Succinia, Cyclostoma, &c.*

Near the junction of the ferruginous sand and "blue" clay many trunks of oak and other trees are seen projecting, often converted into a blackish-brown impressible charcoal or brown coal.

We were not able to discover an instance where the bones were fairly imbedded in the "blue" clay. They appear to originate in the ferruginous sand, and to be encrusted with the same material.

Though the ferruginous sand and "blue" clay lie at a lower level than the fine silicious marly earths, I am not quite certain whether the former may not have been deposited subsequently, unconformably on the slope of the latter. If not unconformable, then the bone bed is older than the silicious marly earths.

One thing, however, is very certain, both from the position of these bones and those found, under analogous circumstances, in the banks of the Ohio, below Evansville, Vanderburg county, Indiana, that they are, comparatively speaking, of a *very recent date*, at least as recent as the origin of most of the existing species of univalve shells now inhabiting the Ohio river and its tributaries.

The bones of the *Megalonyx* sent to you for description were not found all together, or at one time, but were picked up from time to time, and from year to year, as they happened to be washed out from their matrix, particularly after recent freshets.

I did not discover any further remains of edentata when I visited the locality last June, but obtained many horns and bones of deer, and probably of other ruminating animals; but, unfortunately, my collection, made at that time, has all been lost in the wreck of the Cape May, sunk this Summer in the Ohio river, near Mount Vernon.

Full descriptions, with drawings, have since appeared in the above named memoir, of these very remarkable bones of fossil edentata.*

The clay analysed by Dr. Peter, No. 4 of his report, obtained four miles south of Blandville, probably occupies the same geological position as bed No. 5 of the above section. In its original bed it has a chocolate color; when dried, however, it is of a light pink grey or pale flesh tint; when exposed to heat, Dr. Peter found that though it at first darkens in color it finally burns white.†

With the proper addition of silica from the specimen No. 238, or other silicious Quaternary beds to prevent its cracking by baking, it will probably be found to be suitable for the manufacture of certain kinds of stone ware or other varieties of pottery.

The argillaceous portions of bed No. 3, when not effervescent with acids, can also be made into stone ware.

In the Quaternary earths of Ballard and Graves counties beds of lignite and brown coal are not uncommon. These have been mistaken for regular coal formations, and have given rise to various reports of the discovery of coal in the Jackson purchase. Some of this lignite has very much the appearance of coal; hence, it is very apt to be mistaken for it; but it is of much more recent date than true coal, and has been formed under entirely different circumstances, and derived from a very different vegetation than that which flourished during the carboniferous era; hence, we not only find variations in the chemical composition of the two combustibles, but what is of still more importance in estimating their comparative value, the extent of the lignite formation is quite limited, at least in this part of the Mississippi valley,‡ and, therefore, not to be depended upon as a *permanent source* of fuel.

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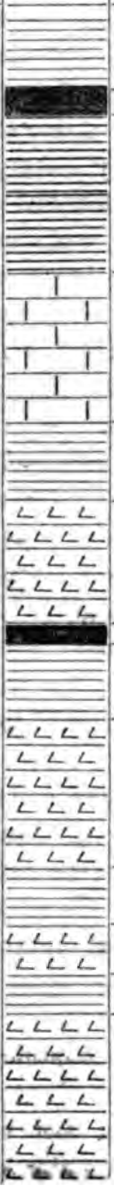
* See Smithsonian Contributions to Knowledge; Memoir on the Extinct Sloth Tribe of North America, by Joseph Leidy, M. D.

† The inhabitants of the neighborhood where it occurs often use it for whitewash.

‡ On the upper Missouri, in Oregon, the Isthmus of Panama and South America, there are lignite formations of much greater extent and value than in the central part of the United States.

HOLLOWAY BORING—Continued.



| Space between main coals. | Thickness, in feet. | Inches. | Depth, in feet. | Inches. | |
|---|---|---|---|---|---|
| | 13 | | 461 | 6 | Shale. |
| | 5 | 6 | 467 | | Coal—Blue and Bonharbor? |
| | 45 | 8 | 512 | 8 | Shale. |
| | 26 | 8 | 539 | 4 | Sandstone. |
| | 11 | | 550 | 4 | Shale. |
| | 22 | 6 | 572 | 10 | Limestone. |
| | 1 | 8 | | | Coal. |
| | 18 | 11 | 593 | 5 | Shale. |
| | 29 | 7 | 613 | | Limestone. |
| | 9 | 8 | 622 | 8 | Shale. |
| | 8 | | 630 | 8 | Limestone. |
| | 5 | | 635 | 8 | Shale. |
| | 33 | 4 | | | Limestone. |

to (409) four hundred and nine feet below low water.

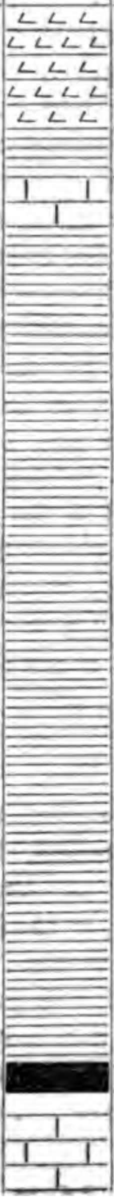
Unfortunately no strict account was kept of the first (80) eighty feet; but I am able to supply this deficiency in part by sections obtained in the vicinity.

The shaft commences about fifty-five (55) feet above low water, and had reached the depth of four hundred and fifty-nine (459) feet last August, when I obtained the records of the shafting from Mr. Burbank, of Henderson.

The two feet to two feet four inches of coal, five to eight feet below low water mark, at Henderson, shown in this section, is probably the equivalent of the "Little Newburg Bed.”

This is a matter that can be fully established only by such a detailed survey as has been made of Union county. If the coal underlaid by limestone, seen six miles below Evansville, above low water, is the “Little Newburg Bed,” and the equivalent, as is supposed, of the 30 inch coal in the Evansville (Bodiam) Shaft, at 110 feet or thereby below the bed of the Ohio river, the same rate of rise, along the south bend of the Ohio river, would not only carry this bed entirely above the Henderson Shaft, but also the Main Newburg (Main Bodiam Bed,) which lies about 100 feet below it.

HOLLOWAY BORING—Continued.

| Space between main coals. | | Thickness, in feet. | Inches. | Depth, in feet. | Inches. | |
|---|---|---|---|---|---|---|
| 401 |  | | | 672 | | Limestone—Continued. |
| | | 5 | | 677 | | Shale. |
| | | 7 | | 684 | | Black, hard rock, with a little grit. |
| | | 179 | 9 | 861 | 9 | Indurated shale. |
| | | 6 | 6 | 868 | 5 | Coal. |
| | | | | | | |

HOLLOWAY BORING—Continued.

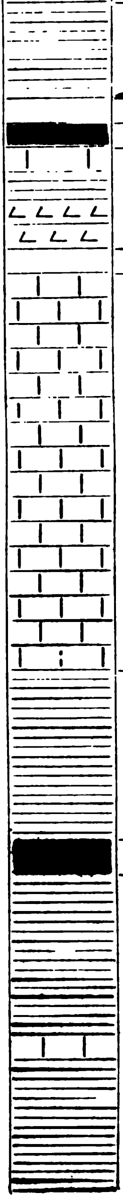
| Space between main coals. | | Thickness, in feet. | Inches. | Depth, in feet. | Inches. | |
|---|---|---|---|---|---|---|
| | ▦ | 156 | | 1024 | 5 | Sandstone. |

SECTION OF SHAFT SUNK BY HENDERSON COAL COMPANY, AT HENDERSON, HENDERSON CO., KY

| Space between main coals. | | Thickness, in feet. | Inches. | Depth, in feet. | Inches. | |
|---|---|---|---|---|---|---|
| | | | | | | Top of Shaft. |
| | | 20 | | 20 | | High water. |
| | | 40 | | 40 | | |
| | ■ | | 18 | | | 18 inch coal. |

My present impression, however, is that the 30 inch coal, overlying limestone, 5 or 6 miles below Evansville, is brought up there by a local wave or anticlinal axis, which carries it down again, and that the average rise between the Bodiam mine and the Henderson shaft is only about 100 feet. This opinion is based on the following data: The Main Newburg bed lies in the shaft above that town, about 27 feet below the Ohio river. If, as is generally conceded, the coal on Green river, at the foot of lock and dam No. 1, is the same bed, then there is a southerly rise between these two localities of only 30 or 40

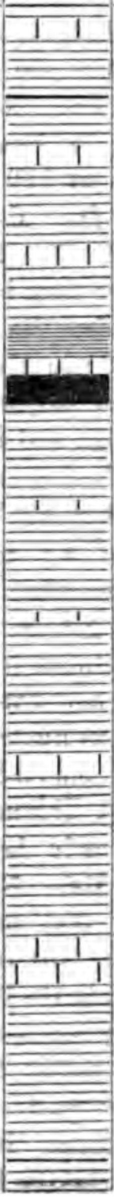
HENDERSON COMPANY SHAFT—Continued.



| Space between main coals. | Thickness, in feet. | Inches. | Depth, in feet. | Inches. | |
|---|---|---|---|---|---|
| | 20 | | | | Gritty indurated shale, with impressions of stigmaria and lepidodendron. |
| | | | 60 | | Low water. |
| | | 4 | | | |
| | 2 | 4 | | | Coal—Little Newburg. |
| | | | | | Fire clay, gritty. |
| | | | 80 | | Place of Main Newburg limestone. |
| | 6 | | 86 | | Shale. |
| 108 | | | | | Schistose sandstone. |
| | 53 | | | | Light grey argillaceous sandstone. |
| | | | 139 | | |
| | 34 | | | | Dark tough shale. |
| | | | 175 | | |
| | 4 | | 179 | | Coal—Main Newburg |
| 87 | | | | | |
| | 84 | | | | Grey indurated argillaceous shale, with some sandstone. |

feet. It is admitted that the Main Newburg and Bodiam coal, 210 feet below the Ohio river, are identical; this gives a dip or fall, from Newburg to Evansville, of 180 or 190 feet, about N. 85° W. The course from lock and dam No. 1, on Green river, to the Holloway borings, and also to Henderson, is about N. 45° W., hence we may expect to find the same general dip as between Newburg and Evansville, with a somewhat diminished angle. This must inevitably bring the Main Newburg coal more than 100 feet down in the Holloway borings.—The bed at 161 corresponds in thickness. It is true that the 100

HENDERSON COMPANY SHAFT—Continued.



| Space between main coals. | Thickness, in feet. | Inches. | Depth, in feet. | Inches. | |
|---|---|---|---|---|---|
| | | | 263 | | Grey indurated argillaceous shale, with some sandstone —Continued. |
| | 3 | 6 | 266 | 6 | Hard black shale. |
| | 1 | | | | One foot of Sandstone. |
| | 3 | 6 | 270 | | Coal. |
| | 70 | | 340 | | Chiefly shale, mixed with sandstone. |
| | 4 | | 344 | | Sandstone. |
| 184 | 110 | | | | Shale. |

feet of space above that coal in the Bodiam shaft is mostly indurated argillaceous shale, while the upper 46 feet of this space is soft sandstone in Henderson county; but where there is a good natural section of this space above the Upper Newburg shaft, there is a considerable quantity of soft sandstone in the upper part of the space; so that this peculiarity in the lithological character of the strata in the Bodiam shaft is not a conclusive argument against the identity of the coal. Again, between the Holloway borings and the measures passed through in the Henderson shaft there is a striking analogy, and, if we assume the

HENDERSON COMPANY SHAFT—Continued.

| Space between main coals. | | Thickness, in feet. | Inches. | Depth, in feet. | Inches. | |
|---|---|---|---|---|---|---|
| | ▤ | | | | | Shale—Continued. |
| | ■ | 5 | | 459 | | Coal—Blue and Bonharbor? |

rate of dip between the two localities at 70 to 80 feet, it brings a *twin vein*, reported in the Holloway borings between 60 and 70 feet from the top, down to near low water of the Ohio river, at Henderson, where there are also two coals, one of 18 and the other of 28 inches, *in close proximity;* the latter being a little below low water of the Ohio river, at the Henderson shaft, with a 4½ foot bed 93 feet below it. Moreover, the rate of southerly rise from Newburg to lock and dam No. 1, if applied to the horizontal distance from the Bodiam mine south to Henderson, will be found sufficient to elevate the strata only about 80 feet, and bring the Main Bodiam coal to about 100 feet below the Ohio river, where the 4½ foot bed of the Henderson shaft is situated. The fossil plants, too, found in the argillaceous strata above both coals, are very similar.

The limestone which lies eight to ten feet below this "Little Coal," at Newburg, is not reported, it is true, in the records of the strata passed through in the Henderson shaft; but I saw what appears to be the equivalent of this limestone in the bank of the Ohio river, only one mile and a half above Henderson, eleven feet above low water.

The space between the two-foot coal, a few feet below low water mark, in the section, and the next four-foot coal, is within a few feet of the same distance between the Little and Main Newburg beds.

The five-foot coal which lies two hundred and seventy feet below the four-foot coal in this shaft, and at a depth of four hundred and sixty (460) feet in the Holloway borings, is probably the equivalent of the Bonharbor coal and the Blue coal of Union county; but before this point can be fully established, it will be necessary to extend the detailed survey through Daviess and Henderson counties.

The twenty-inch coal. reported at a depth of (572) five hundred and seventy-two feet in the Holloway borings, is, in all probability, the equivalent of the thirteen-inch coal found in the bed of the Ohio river, below the Coal Haven Factory, on the Kentucky side, and five feet above low water of the Ohio river on the Indiana shore, between Enterprise and the head of French island; and the thick limestones, associated with shales above and below it, which are reported in the Holloway borings, I believe will prove to be principally bands of calcareous ironstones, alternating with shales and associated with a dark bituminous fossiliferous limestone, containing *Spirifer faciger of Keiserling*, *Chonetes mesoloba*, *Pratten and Norwood*, &c., which lies about five feet above the top of the thirteen-inch coal above the head of French island. The last coal reached in the Holloway borings, at a depth of eight hundred and sixty (860) feet, probably corresponds to a coal lying under a great mass of shales in the head of the valley of Cane creek, and between Wash creek and Bethel hill, in Union county, and superimposed on the great mass of sandstone constituting the body of that hill. These sandstones have been passed through in the Holloway borings, under the last mentioned coal, one hundred and fifty-six (156) feet, extending to the depth of ten hundred and twenty-four feet from the surface of the ground.

In the nine hundred (900) feet of strata lying between Bethel hill and the top of the sandstone which caps the Lower Coal Measures, four other beds of coal have been discovered by the detailed survey of Union county, varying from two to three feet, and perhaps a fifth.

These Upper Coal Measures, therefore, comprise at least eight workable beds of coal in the space of nearly two thousand (2000) feet, occurring at the following distances apart:

| | *feet.* | *feet.* |
|---|---|---|
| 1st Coal—Little Newburg, - - - - - | | 2½ to 3. |
| Space, - - - - - - - - | 100. | |
| 2d Coal—Main Newburg, - - - - - | | 4. |
| Space—in shaft 88 in boring, - - - - | 97.5 | |

| | feet. | feet. |
|---|---|---|
| 3d Coal, | | 2½ to 3. |
| Space—in shaft 184 in boring, | 196.6 | |
| 4th Coal—Bonharbor and Blue, | | 5½ to 5. |
| Space in boring, | 400.5 | |
| 5th Coal—Cane creek coal, | | 6.? |
| Space on section, | 400. | |
| 6th Coal—Davis coal, | | 2.6 |
| Space, | 253.6 | |
| 7th Coal—Cypress coal, | | 2 to 3. |
| Space, | 303. | |
| 8th Coal—1st over the Anvil Rock. | | 3.? |
| | 1,750.3 | 29.6 |

It is truly remarkable, that in these Upper Coal Measures the spaces between the coals, by actual measurement, in sections, borings, and shafts, do not differ more than three and a half (3½) feet, in any one instance, from the numbers one hundred (100), ~~one hundred (100)~~, two hundred (200), four hundred (400). The other three spaces, calculated from average dip and horizontal distance, measured on the Geological Map of Union county, constructed by the Topographical Assistant, give four hundred (400), two hundred and fifty (250), and three hundred (300) feet, within three and a half (3½) feet. Moreover, a twenty (20) inch seam intervening in the fourth space, of exactly four hundred and a half (400½) feet, lies within six feet of half the distance, or two hundred (200) feet, and another thin coal of six inches come in within twenty-two (22) feet of midway, or a distance of two hundred (200) feet below the fourth coal, and above the fifth.

Do not these facts evidently indicate some persistent uniform law, not only in the rate of deposition of the sediments which constitute the coal measures, but in the upward and downward movements of the earth's surface, and also in the periods which elapsed between the vast growths of the carboniferous forest.

We shall see hereafter how far this law is applicable to the Lower Coal Measures.

It is to be observed, however, that towards the margin of the coal field these spaces are contracted in their dimensions, and the coals come much closer together—in some instances within five feet. This is a variation to be anticipated from the original basin-shaped conformation of coal fields. Though the *spaces* between the coal beds thin out towards the south, this rule cannot be applied to the *coal beds*. Many of these are, in fact, thicker towards the margin than in the interior of the coal field; arising, no doubt, from the longer duration of the extra-tropical forest growth before submergence; thus affording an opportunity for a greater accumulation of the vegetable matter which produced the coal. Some beds of coal may diminish, and even run out entirely, towards the confines of the basin; but, I believe, as a general rule, it will be found, that most of the beds are *thicker* and *closer together* within a few miles of the extreme limits, than in the centre of a coal field.

Still, above the first or highest of the coals, included in the foregoing section, there are nearly six hundred (600) feet of strata, constituting the most recent terminating portion of these Upper Coal Measures. The sections obtained in Grundy's ridge, together with the borings made by Messrs. Riddle & Houston, of three hundred and thirty-four (334) feet, in Union county, nearly opposite Wabash island, and those made by Messrs. Berry and McGinnis, on Highland creek, near Uniontown, of one hundred and seventy (170) feet, have afforded considerable insight into the highest portions of the coal measures of the south-western coal field, with which we are acquainted; enough to render it highly probable that there is but one workable bed of coal near the bottom or base of these six hundred (600) feet. There are, however, some nine thin seams of coal besides—some of them mere streaks of coaly matter. They occur in the following order and distances apart:

| | *feet.* | *feet.* |
|---|---|---|
| Space, | 50. | |
| 1st Coal—above Carthage limestone, | | 0.8 |
| Space, | 50. | |
| 2d Coal—coal under Carthage limestone, | | 0.4 |
| Space, | 43. | |
| 3d Coal, | | 0.4 |
| Space, | 89. | |
| 4th Coal—very shaly, | | 2.6 |
| Space, | 115. | |
| 5th Coal—impure, | | 1.1 |
| Space, | 41.6 | |
| 6th Coal—streak. | | |
| Space, | 36.3 | |
| 7th Coal, | | 0.4 |

| | feet. | feet. |
|---|---|---|
| Space unknown. | | |
| 8th Coal? | | |
| Space, | 103.1 | |
| 9th Coal—workable, | | 3.3 to 3.6 |
| Space, | 29.1 | |
| 10th Coal, | | 5. |

In this terminating map of the Coal Measures the spaces are not quite so regular in their occurrence; yet the greatest deviation from a constant and simple multipule is only thirteen (13) feet nine inches, although it is evident that here, at the conclusion of the carboniferous era, the laws which regulated the coal formation were gradually ceasing to exist, and the carboniferous flora approaching extinction.

The total thickness of the Upper Coal Measures, as far as at present ascertained, is about two thousand four hundred (2,400) feet. These are shown on section 1, and in part also on diagram No. 2.

If we include in the list of coals in these measures all the thin, as well as the thick coals, there are at least twenty (20) beds, their united total thickness being upwards of forty (40) feet.

The following are the analyses of some of the most available of the Upper Coal beds:

*Analsis of Cook's coal, on Green river, Henderson county, Ky., equivalent of the Newburg main coal.*

| | | |
|---|---|---|
| Total volatile matter, | | 44.5 |
| Total coke, | | 55.5 |
| | | 100.0 |
| Moisture, | 11.5 | |
| Volatile combustible matter, | 33.0 | |
| Fixed carbon in coke, | 47.0 | |
| Ashes, | 8.5 | |
| | 100.0 | |

*Analysis of Bonharbor coal, Daviess county, Ky., No. 175, middle part.*

| | | |
|---|---|---|
| Specific gravity, | 1.273 | |
| Total volatile matter, | | 48.3 |
| Total Coke, | | 51.7 |
| | | 100.0 |

| | |
|---|---|
| Moisture, | 7.0 |
| Volatile combustible matter, | 41.3 |
| Fixed carbon, | 46.7 |
| Ashes, (light grey, almost white,) | 5.0 |
| | 100.0 |

Did not puff up much in coking; throws out spangles; much calc. spar in thin layers in the joints of this coal; a good deal of pyrites intermixed.

*Analysis of two inches of hard, close-textured, compact, cannel-like coal, on top of Bonharbor coal. No.* 176.

| | | |
|---|---|---|
| Specific gravity, | 1.526 | |
| Total volatile matter, | | 38.0 |
| Coke, | | 62.0 |
| | | 100.0 |
| Moisture, | 4.5 | |
| Volatile combustible matter, | 33.5 | |
| Fixed carbon, | 37.0 | |
| Ashes, | 25.0 | |
| | 100.0 | |

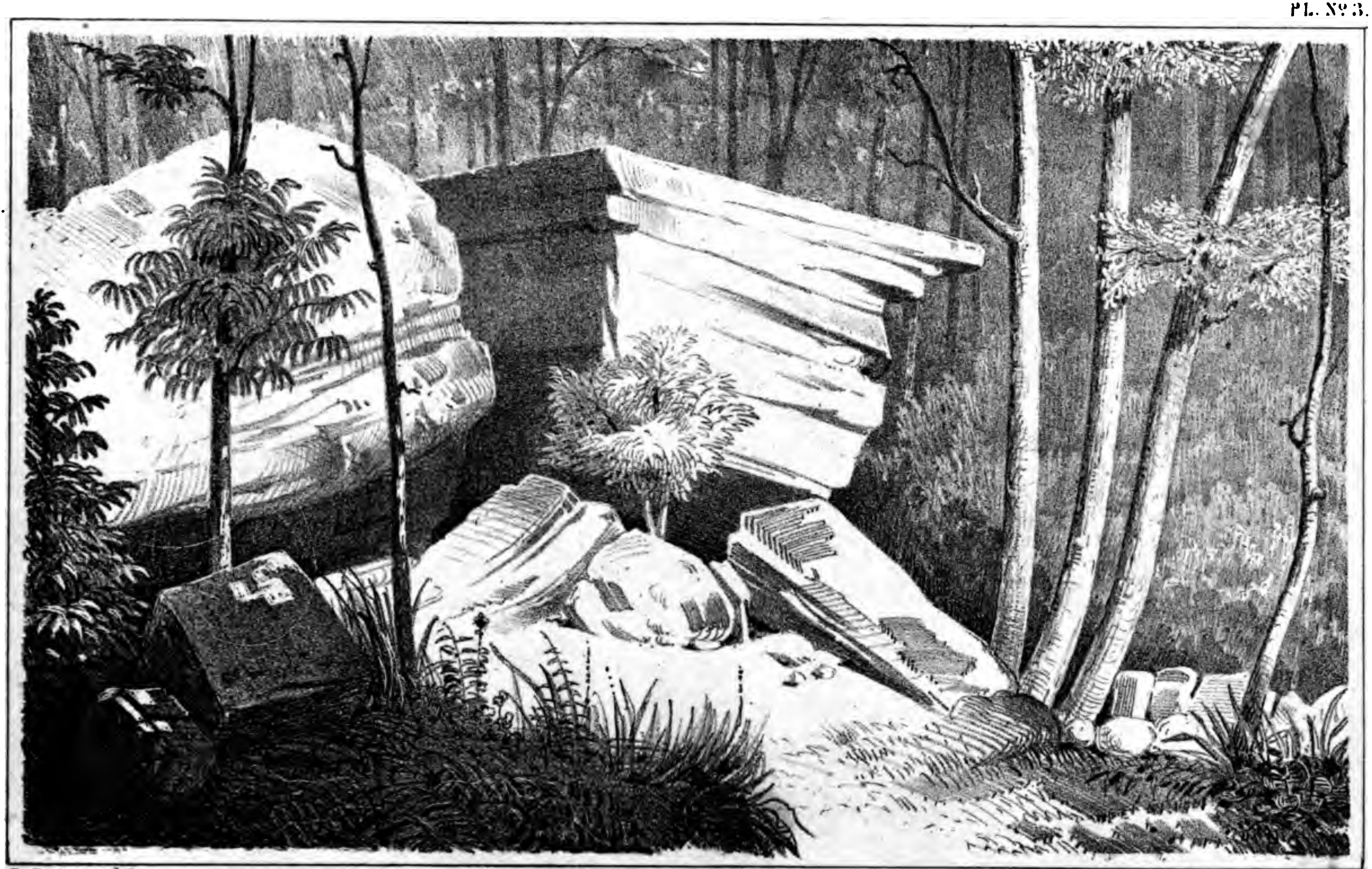
*Analysis of Wolf Hill coal, Daviess county. No.* 189.

| | | |
|---|---|---|
| Specific gravity, | 1.228 | |
| Total volatile matter, | | 42.4 |
| Coke, | | 57.6 |
| | | 100.0 |
| Coke, in part crystalline. | | |
| Moisture, | 12.0 | |
| Volatile combustible matter, | 30.4 | |
| Fixed carbon, | 56.6 | |
| Ashes, | 1.0 | |
| | 100.0 | |

*Two-foot Henderson coal, equivalent of the Little Newburg? No.* 206.

| | | |
|---|---|---|
| Total volatile matter, | | 45.5 |
| Coke, | | 54.5 |
| | | 100.0 |
| Moisture, | 6.0 | |
| Volatile combustible matter, | 39.5 | |
| Fixed carbon, | 44.5 | |
| Ashes, (grey,) | 10.0 | |
| | 100.0 | |

PL. No. 3.

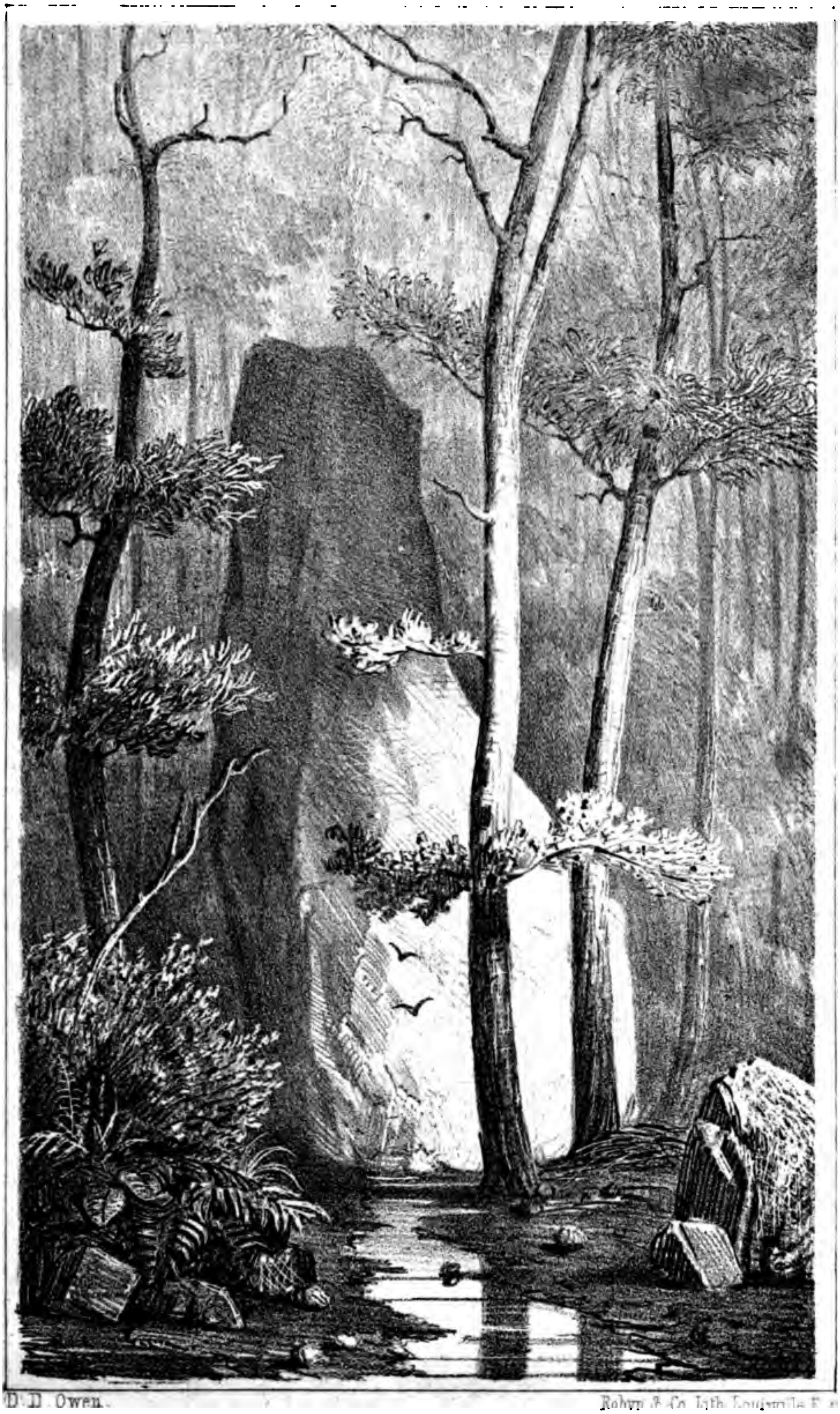


D. D. Owen del.

Robyn & Co. Lith. Louisville, Ky.

MASS OF SANDSTONE FROM WHICH THE ANVIL ROCK DERIVES ITS NAME UNION COUNTY KENTUCKY.

PL. No 1



D. D. Owen. Robyn & Co. Lith. Louisville

DETACHED MASS FROM THE ANVIL ROCK UNION COUNTY.

*Analysis of thirteen-inch coal, head of French island, Ohio river.*

| | | |
|---|---|---|
| Total volatile matter, | | 47.0 |
| Coke, | | 53.0 |
| | | 100.0 |
| Moisture, | 6.0 | |
| Volatile combustible matter, | 41.0 | |
| Fixed carbon, | 46.5 | |
| Ashes, | 6.5 | |
| | 100.0 | |

The Lower Coal Measures are separated from these Upper Coal Measures by a massive sandstone formation, which is universally known in South-western Kentucky by the name of the "*Anvil Rock.*" It has received this appellation on account of the resemblance to an anvil of two conspicuous masses of this formation, situated on its northern escarpment, on Hines creek.

Plate No. 3 represents one of these masses, in which the anvil form can be easily recognized, and from which probably the name was in reality originally derived; Plate No. 4, the other mass which was first pointed out to me as the "*Anvil Rock.*" In this the anvil shape is not so clearly defined, though from a certain point of view this also has the appearance of an anvil, the point being directed upwards.

From this local appellation the name has been extended to the whole range of this sandstone formation, and serves as a popular and well understood term in Union county, Kentucky, by which to distinguish this prominent capping member of the Lower Coal Measures, lying between it and the conglomerate or pebbly sandstone, which may be regarded as the base of the productive coal measures.

In this geological position are situated the richest coal beds of the south-western coal field. The whole space, which is over nine hundred (900) feet, including the Anvil Rock, containing ten workable beds of coal, of the following thickness and relative position:

| | *feet.* | *feet.* |
|---|---|---|
| Space, including Anvil sandstone, | 45. | |
| 1st Coal under Anvil Rock, | | 1½ to 3. |
| Space, | 48. | |
| 2d Coal—Middle coal, | | 3. |
| Space, | 67. | |
| 3d Coal—Main five-foot coal, | | 4.8 to 5. |

| | *feet.* | *feet.* |
|---|---|---|
| Space, | 86.* | |
| 4th Coal—Well coal, | | 2. to 2.6 |
| Space, | 112.† | |
| 5th Coal—"Little Vein," or three-foot coal, | | 3. |
| Space, | 65.‡ | |
| 6th Coal—four-foot coal, | | 4. |
| Space, | 95. | |
| 7th Coal—Curlew coal, four-foot, with clay parting, | | 2.6 |
| Space, | 157. | |
| 8th Coal—Ice-house coal, | | 2.4 to 2.6 |
| Space, | 154. | |
| 9th Coal—Bell coal, | | 4. to 3. |
| Space, | 73. | |
| 10th Coal—Cook coal, | | 2.6 to 3. |
| Thickness of coal, | | 31.6 |
| Thickness of spaces, | 998. | |
| | 31.6 | |
| Thickness of spaces and coals united, | 1,029.6 | |

See section No. 1 and diagram No. 1.

It will be perceived that the spaces in these Lower Coal Measures are nearly as regular as in the upper coal measures.

Taking into account averages deduced from two localities the spaces do not differ more than five feet from the numbers 50, 100, and 150. The space between the middle and main five-foot coal overruns the regular number by seventeen feet, and the space between the Bell and Cook underruns it by twenty-seven feet, but this is the space above the first coal over the conglomerate, just at the commencement of the true carboniferous era; and it is to be observed, also, that there is a shaly space of twenty feet between it and the conglomerate, which, if added, would make the space from the Bell coal to the conglomerate, including the thickness of the Cook coal, ninety-six feet. Moreover, there is nearly the same regularity in the position of several minor thin seams of coal, intervening between some of these thick beds, for instance: one which has been observed on the Saline, about fifty feet under the main five-foot coal, lies very nearly fifty feet under the Curlew coal, and another, which lies forty-three and a third feet above the Ice-House coal. This wonderful regularity of position of the principal beds of coal of the south-western coal field is not only a matter of interest, as establishing the existence of uniform laws regulating the succession of events, at so remote a period as the carboniferous era, but also on account of the important practical bearing it has, in indicating the position in which one of the most valuable mineral products, concealed within the bowels of the earth, can be found.

---

* On the Saline this space is 100 feet.

† On the Saline this space is 95 feet. The average of the two localities is 103 feet.

‡ On the Saline this space is only 32 feet. The average between the two localities is 48.6 feet.

Starting from the base of the Anvil Rock, in the space of nine hundred and fifty-five (955) feet, there are ten beds of coal, having a united thickness of over thirty feet. All of these are workable, unless it be the seventh, or Curlew coal, which, having two clay partings, may not afford more than two feet of good coal, and perhaps, also, the fourth, or Well coal, which is only about two and a half feet thick. There are besides, in this space, six or eight minor thin seams, having a thickness, altogether, of perhaps two to four feet, but none of them of any practical value at the present time.

The upper four hundred feet of this space is the most productive part of the coal measures, since it includes from five to six of the best coal beds to be found in the whole three thousand four hundred and twenty-nine (3,429) feet of the carboniferous strata, at present known, to-wit:

The Upper, or first coal under the Anvil Rock.
The Middle coal.
The Main five-foot, or Mulford coal.
The Well coal, or Water coal.
The Little Vein, or three-foot coal; and
The four-foot coal.

The total average thickness of these coals may be taken at eighteen (18) feet.

The average specific gravity of these coals may be taken at about 1.284, i. e. every *solid* cubic foot will weigh within a fraction of eighty pounds, which may, therefore, safely be regarded as a bushel, since in weight it is four pounds over the legal standard in Kentucky. Hence these six beds are capable of yielding, from every acre of ground under which they extend, over eight hundred thousand (800,000) bushels. Throwing off one-fourth for waste, slack, &c., it will still yield more than six hundred thousand (600,000) bushels or solid cubic feet. Allowing a profit of only three cents per bushel, this amounts to eighteen thousand ($18,000) dollars per acre.

Those lands which contain, in addition, the four lower coals, would yield more than half as much more.

The intrinsic value of these coal lands is indeed almost beyond conception. At the same time, in estimating the availability of coal, this fact must always be held in view, that the best appointed coal mines now in operation in the Western States cannot average a regular delivery of (10,000) bushels per day, or three million (3,000,000) bushels per annum; hence, it would require one year to work out eight acres, since one-half should be left as pillars of support, only to be removed when the whole coal lands are undermined. This standing coal can, however, be finally mined at much less expense than the first half. From five to six cents profit may be safely allowed on the standing coal, supposing it to bring the present price of eight cents per bushel.

In this calculation the Well coal is not included, because it is doubtful whether it may be considered a workable coal.

The geological level of this coal is, wherever it is reached, the source of large supplies of water, which can with great advantage be applied for steam and other purposes required at the mines.

The whole of the ten beds of coal, above described, crop out above high water, in the distance of less than two miles, between the Mulford mines and the Finnie bluff.

In consequence of the rise of the conglomerate and millstone grit to the south-west, the coal measures have a dip to the north-east—usually north 18° east—at the rate of about 4° 45′; i. e., descending one foot in every twelve feet of horizontal distance. But this rate of dip declines as the strata reach the flats of Cypress.

The course of the dip is also liable to variations, in consequence of the deflection of the strike line to the north, as it proceeds in the direction of the Bald Hill disturbance, and to the south-east as it approaches the Caseyville conglomerate. The degree of dip also changes, even along the strike line, by reason of the strata being thrown into a series of waves or wrinkles at right angles to the dip, or into elongated dome-shaped vaults, and corresponding depressions, while conforming to the diminished space into which they were compressed during shrinkage, as well as by the disturbances and subterranean movements which brought the inferior rocks to the surface, and the lateral compressing force acting between the uplift of the Bald Hill, on the north, and the Battery Rock and Caseyville conglomerate, on the south.

One of these synclinal folds exits in the valley of Hines creek, flanked on the north and south by corresponding anticlinal wrinkles, or axes of elevation, which brings the upper beds of the Coal Measures to the surface on either side of that valley. For more particular information and details in regard to the peculiar character of this remarkable geological structure in the Coal Measures of Union county, I beg to refer you to the Geologico-Topographical Report of S. S. Lyon.

The following chemical analyses of the most important of the coals from the Lower Coal Measures, under the Anvil Rock, are here submitted:

*Analysis of Mulford's main or five-foot coal, Union county, Ky. No.* 185.

| | | |
|---|---|---|
| Specific gravity, | 1.308 | |
| Total volatile matter, | | 39.5 |
| Coke, | | 60.5 |
| | | 100.0 |
| Coke inflated. | | |
| Moisture, | 3.5 | |
| Volatile combustible matter, | 36.0 | |
| Fixed carbon, | 57.5 | |
| Ashes, (light grey,) | 3.0 | |
| | 100.0 | |

*Bell's coal, Crittenden county, Kentucky.*

| | No. 173. | | No. 174. | |
|---|---|---|---|---|
| | MIDDLE PART. | | UPPER PART. | |
| Specific gravity, | 1.274 | | 1.337 | |
| Total volatile matter, | | 39.4 | | 33.2 |
| Coke, | | 60.6 | | 66.8 |
| | | 100.0 | | 100.0 |
| Moisture, | 3.0 | | 4.0 | |
| Volatile combustible matter, | 36.4 | | 29.2 | |
| Fixed carbon, | 57.6 | | 56.8 | |
| Ashes, (pale flesh color,) | 3.0 | | (greyish flesh color,) 10.0 | |
| | 100.0 | | 100.0 | |

The middle part puffs up in coking; coke bright but cellular; adheres but very slightly in burning.

The upper part has a more dull and slaty appearance than the middle of the same bed; did not puff up so much in coking; some excrescences on the surface.

*Analysis of Mulford's four-foot bed of coal, Union county, Ky. No.* 186.

| | | |
|---|---|---|
| Specific gravity, | 1.284 | |
| Total volatile matter, | | 42.4 |
| Coke, | | 57.6 |
| | | 100.0 |

Coke slightly inflated.

| | |
|---|---|
| Moisture, | 5.0 |
| Volatile combustible matter, | 37.4 |
| Fixed carbon, | 50.6 |
| Ashes, (light grey,) | 7.0 |
| | 100.0 |

*Analysis of "Little Vein," Mulford's Mine, Union county, Ky. No.* 187.

| | | |
|---|---|---|
| Specific gravity, | 1.306 | |
| Total volatile matter, | | 36.7 |
| Coke, | | 63.3 |
| | | 100.0 |

Coke slightly inflated.

| | |
|---|---|
| Moisture, | 4.0 |
| Volatile combustible matter, | 32.7 |
| Fixed carbon, | 55.3 |
| Ashes, (light grey,) | 8.0 |
| | 100.0 |

*Analysis of the cannel part of the Little Vein. No.* 208.

| | | |
|---|---|---|
| Specific gravity, | 1.364 | |
| Total volatile matter, | | 40.3 |
| Coke, | | 59.7 |
| | | 100.0 |

Coke very much inflated.

| | |
|---|---|
| Moisture, | 2.0 |
| Volatile combustible matter, | 38.3 |
| Fixed carbon, | 47.7 |
| Ashes, | 12.0 |
| | 100.0 |

*Analysis of Mulford's middle coal, Union county, Ky.; (sample from "tailings.")*
*No.* 184.

| | | |
|---|---|---|
| Specific gravity, | 1.402 | |
| Total volatile matter, | | 38.7 |
| Coke, | | 61.3 |
| | | 100.0 |

Coke unchanged.

| | |
|---|---|
| Moisture, | 14.0 |
| Volatile combustible matter, | 24.7 |
| Fixed carbon, | 51.3 |
| Ashes, (reddish grey,) | 10.0 |
| | 100.0 |

*Analysis of Ice-House coal, Union county, Ky. No.* 188.

| | | |
|---|---|---|
| Specific gravity, | 1.349 | |
| Total volatile matter, | | 36.5 |
| Coke, | | 63.5 |
| | | 100.0 |

Coke slightly changed, compact.

| | |
|---|---|
| Moisture, | 4.0 |
| Volatile combustible matter, | 32.5 |
| Fixed carbon, | 58.5 |
| Ashes, (reddish grey,) | 5.0 |
| | 100.0 |

*Analysis of the upper part of first coal under the Anvil Rock, Union county, Ky.*
*No.* 183.

| | | |
|---|---|---|
| Specific gravity, | 1.282 | |
| Total volatile matter, | | 48.7 |
| Coke, | | 51.3 |
| | | 100.0 |

Coke compact.

| | |
|---|---|
| Moisture, | 1.0 |
| Volatile combustible matter, | 47.7 |
| Fixed carbon, | 42.3 |
| Ashes, (reddish grey,) | 9.0 |
| | 100.0 |

*Analysis of the lower part of the first coal under the Anvil Rock, Union county, Ky. No.* 207.

| | | |
|---|---|---|
| Specific gravity, | 1.365 | |
| Total volatile matter, | | 39.6 |
| Coke, | | 60.4 |
| | | 100.0 |

Coke very much inflated.

| | |
|---|---|
| Moisture, | 3.0 |
| Volatile combustible matter, | 36.6 |
| Fixed carbon, | 47.4 |
| Ashes, (reddish grey,) | 13.0 |
| | 100.0 |

*Analysis of Mr. Hawes' main coal, at Hawesville, Hancock county, Ky. No.* 178.

| | | |
|---|---|---|
| Specific gravity, | 1.397 | |
| Total volatile matter, | | 47.0 |
| Coke, | | 53.0 |
| | | 100.0 |

Coke slightly inflated.

| | |
|---|---|
| Moisture, | 8.0 |
| Volatile combustible matter, | 39.0 |
| Fixed carbon, | 46.0 |
| Ashes, (white,) | 7.0 |
| | 100.0 |

*Analysis of Roberts' coal, on Muddy river, now owned by the Green River Coal, Iron, and Manufacturing and Mining Company, Muhlenburg county, Ky. No.* 191.

| | | |
|---|---|---|
| Specific gravity, | 1.218 | |
| Total volatile matter, | | 41.48 |
| Coke, | | 58.52 |
| | | 100.00 |

Coke slightly inflated.

| | |
|---|---|
| Moisture, | 5.00 |
| Volatile combustible matter, | 36.48 |
| Fixed carbon, | 54.72 |
| Ashes, (white,) | 3.80 |
| | 100.00 |

*Analysis of Capt. Davis' Jakefield coal, Hopkins county, Ky. No.* 193.

| | | |
|---|---|---|
| Specific gravity, | 1.294 | |
| Total volatile matter, | | 43.75 |
| Coke, | | 56.25 |
| | | 100.00 |

Coke not much inflated.

| | |
|---|---|
| Moisture, | 4.00 |
| Volatile combustible matter, | 39.75 |
| Fixed carbon, | 50.75 |
| Ashes, (nearly white,) | 5.50 |
| | 100.00 |

*Analysis of the Gamblin coal, belonging to Burbank & Co., Hopkins county, Ky. No.* 194.

| | | |
|---|---|---|
| Specific gravity, | 1.270 | |
| Total volatile matter, | | 42.47 |
| Coke, | | 57.53 |
| | | 100.00 |

| | |
|---|---|
| Moisture, | 3.40 |
| Volatile combustible matter, | 39.07 |
| Fixed carbon, | 56.13 |
| Ashes, (pale flesh color,) | 1.40 |
| | 100.00 |

*Analysis of Box Mountain Spring coal, Hopkins county, Ky. No.* 195.

| | | |
|---|---|---|
| Specific gravity, | 1.339 | |
| Total volatile matter, | | 40.75 |
| Coke, | | 59.25 |
| | | 100.00 |

| | |
|---|---|
| Moisture, | 6.00 |
| Volatile combustible matter, | 34.75 |
| Fixed carbon, | 50.25 |
| Ashes, (light greyish flesh color,) | 9.00 |
| | 100.00 |

*Analysis of Capt. Davis' Pigeon Run coal, Hopkins county, Ky. No.* 198.

| | | |
|---|---|---|
| Specific gravity, | 1.283 | |
| Total volatile matter, | | 46.8 |
| Coke, | | 53.2 |
| | | 100.0 |

| | |
|---|---|
| Moisture, | 5.5 |
| Volatile combustible matter, | 41.3 |
| Fixed carbon, | 49.7 |
| Ashes, (white,) | 3.5 |
| | 100.0 |

In Dr. Peter's Report will be found several other analyses of coals from this coal field.

For some general remarks and comparisons, I shall select the main five-foot coal, the third under the Anvil Rock, as being the coal which has been most extensively worked on the south-west side of the coal basin. It is a free-burning, bituminous coal, of rather a reedy structure in some of its horizontal partings, presenting alternate layers of bright resinous and dull splint seams, the former predominating. In coking it swells up slightly, losing its original contour, but forming a coke of medium density, which, when manufactured on the large scale, would probably have a specific gravity of about 0.8.

In its chemical composition it approximates closely to the well known Newcastle coal, but is of rather higher specific gravity—the Newcastle having a specific gravity of 1.257, while the main five-foot bed varies from 1.284 to 1.308. In its specific gravity it more nearly approaches to the Midlothian coal, of Virginia, analyzed by Johnson, though it has two or three per cent. more fixed carbon, and four to five per cent. more volatile matter, and less ashes, than the Midlothian coal. One hundred parts of nitrate of potash require twenty-two parts for complete decomposition, while one hundred parts of the best coals found in Pennsylvania and Virginia, west of the Alleghany mountains, require about twenty parts.

The sulphur, by two separate experiments, amounted to from one to 1.68 per cent.

Judging from the researches of Johnson, Hayes, Rogers, De la Beche, and Playfair, on coals of this country and Europe, almost identical in chemical composition, and of nearly the same specific gravity, analagous structure and appearance, the practical properties of the main five-foot coal, of the Lower Coal Measures, may be briefly sumed up:

In weight it takes an intermediate rank—a solid cubic foot weighing within a fraction of eighty (80) pounds, while a cubic foot in lumps weighs about forty-five (45) pounds.

For rapidity of ignition it takes a high rank, requiring only from forty-eight to fifty-four minutes to bring a boiler into steady action, when consuming from eight to nine pounds on every square foot of grate per hour. One pound of coal will produce about eight and a half pounds of steam at 212°, and about nine pounds of steam, at 212°, for every one pound of combustible matter.

For relative completeness of combustion it takes an intermediate rank. For freedom from waste in burning it takes a high rank—the total average waste, in ashes and cinder, being about seven to eight per cent.

One cubic foot of coal in lumps will generate about three hundred and fifty pounds of steam at 212°.

For every one of combustible matter it reduces about twenty-seven parts of litharge, while the strongest anthracites reduce from thirty-two to thirty-three parts.

Sixty pounds of coal would be required to produce from thirteen to fourteen links of chain cable, of one and three-eighth inches in diameter.

For combined evaporative speed and power, for equal bulks, it takes a range inferior only to the semi-anthracites, and some of the semi-bituminous coals. The same remarks, with but little modification, will apply to the three-foot and Bell coal, and probably, also, to the four-foot coal, which, on an average, differ but little, essentially, from the five-foot bed.

It ought to be remarked, however, in regard to the four-foot coal, that the analysis given does not afford as favorable an impression of this bed as it probably deserves, since the analysis was made upon a specimen taken from under a slack pile, because the old drift made into this bed had fallen in and cut off the communication with the coal in place. Where the bed has been analyzed from other localities it has yielded eight per cent. more fixed carbon in the coke.

The Ice-House coal, if fairly opened, would, undoubtedly, prove to be a superior coal, at least for general manufacturing purposes, since it approaches more nearly, in its structure and manner of coking, to the dry, reedy, splint coals of the Scotch coal fields; it has the dull black aspect, the transverse, tubular fracture splintery, sharp angles, and the dull woody sound when struck with the hammer, and, above all, in coking, it retains nearly the original form of the coal before coking, all of which characters belong to the splint coals, which are more highly esteemed for the blast furnace, even in its raw condition, than the more free burning, soft, resinous coals, possessing a greater per centage of gas and bituminous matter in their composition. It is true that this coal, for equal bulks, will not bring a boiler into full action in quite so short a time as the five-foot coal, which contains more gas and bitumen, but it will have greater reducing powers, i. e. it will abstract more oxygen from the oxydes of the metals, and it will be rather more durable in proportion to the greater amount of fixed carbon; and from the fact of its not swelling up, and becoming cellular during combustion, it will be capable of resisting the action of the blast from the tweers, and hold up a greater burden of ore and flux, which is of great importance in the manufacture of cast-iron.

The light spongy and cellular textured cokes, produced from the soft resinous coals, are driven too fast before the blast, and raise the temperature too high, so as to destroy, in a measure, the chemical affinity existing between the carbon and the iron; they consume too fast, and thus permit the burden to descend too rapidly, before the chemical affinities have had time to arrange the elements, so as to produce the proper quality of soft grey iron; and this is the reason why these soft bituminous coals have a tendency to turn out hard white or, at least, a sharp mottled iron.

The Ice-House coal cannot, however, be mined with as much profit, at present, as the thicker beds, higher and lower in the series, but its association with important beds of calcareous iron-stones, interstratified in the shales immediately overlying it, may hereafter render it well worthy the attention of the manufacturer, since, if these iron-stones should be in request for the manufacture of iron, both the coal and iron-stones could be mined in connection, which would materially reduce the expense attendant on mining, by itself, a coal of two feet three inches to two and one half feet.

The only other coal analysed from the Lower Coal Measures of Union county, which retains its form in coking, is the Middle, or second coal under the Anvil Rock. But this coal yielded eight per cent. less carbon in the coke than the Ice-House coal. It is to be observed, however, in taking the analysis above given, of the Middle coal, that it hardly exhibits a fair comparison, as specimens could only be obtained by laying bare the face of the coal in a ravine where it had long been exposed to disintegrating and decomposing influences, which not only impregnate the coal with moisture, but remove, doubtless, some of its carbon, as carbonic acid and carburetted hydrogen. This coal might, therefore, prove to be a good coking coal, with a sufficient per centage of fixed carbon, if fairly opened.

Many of the intercalated shales, especially in the Lower Coal Measures, are highly ferruginous, and contain more or less iron-stones; some calcareous and some argillaceous; either in bands, balls, or flattened, kidney-shaped masses; sometimes compact, at other times scaling off in concentric layers, which had originally accumulated around a central nucleus.

The spaces to which I would particularly call attention as likely to afford the most abundant supply of iron-stones are, the ten feet of shales over the Ice-House coal.

This mass of argillaceous shale includes from seven to eight distinct bands, partly continuous in their range through the bed, and partly interrupted. I had these shale beds fairly opened, in order to arrive at some definite conclusion as to the amount of iron-stones which they would yield.

The estimate which I form from the view thus obtained, is, that there are from seven to eight layers, here and there interrupted, varying from one to four inches in thickness; the whole may be averaged at two inches in thickness for each band, or sixteen inches in all, throughout the mass, i. e., about one-sixth of the whole ten feet of the roof of the Ice-House coal is calcareous iron-stones.

These iron-stones have a specific gravity varying from 3.135 to 3.591.

A specimen of the fine grained ore, taken from one of the bands of four inches in thickness, and having a specific gravity of 3.591, yielded by analysis,

| | | |
|---|---|---|
| Protoxide of iron, | 49.00 | 43.76 per cent. of pure iron. |
| Peroxide of iron, | 5.60 | |
| Carbonic acid, | 31.00 | |
| Insoluble earthy silicates, | 8.50 | |
| Lime, | 1.25 | |
| Alumina, | 1.50 | |
| Magnesia, | 1.00 | |
| Carbonaceous matter, | 0.85 | |
| Hygrometric water, | 0.30 | |
| Loss, | 1.00 | |
| | 100.00 | |

A more earthy and coarser textured variety, two inches in thickness, and having a specific gravity of 3.340, yielded,

| | | |
|---|---|---|
| Protoxide of iron, - - - | 36.0 | 30.3 per cent. of pure iron. |
| Peroxide of iron, - - - | 4.7 | |
| Carbonic acid, - - - | 23.0 | |
| Lime, - - - - - - | 1.0 | |
| Alumina, - - - - - | 0.2 | |
| Magnesia, a trace. | | |
| Insoluble earth silicates, - | 30.0 | |
| Hygrometric water, - - | 5.0 | |
| Loss, - - - - - - | 0.1 | |
| | 100.0 | |

These ores are essentially carbonates of the protoxide of iron, and capable of yielding in the furnace from thirty to forty per cent. of cast iron.

This species of ore is very commonly manufactured in Scotland into iron, where it is either obtained by stripping, when the amount of superincumbent earth is not too great, or by drifting after it, if under a heavy roof of earth or rocky matter. In that country "this iron-stone occurs in bands of from half an inch to twelve inches. But those of from three, four, five, and six inches are most commonly met with. It is considered in that country that a band of good iron-stone, four inches thick, is worth mining after, and will sufficiently repay the expense of the operation."

It is obvious, therefore, that this deposit, especially in connection with valuable coal underlying it, must ultimately be of great importance.

Over the ten-foot shale and iron-stone, covering the Ice-House coal, are a few feet of brown sandstone, which is succeeded, in the ascending order, by other shales which also contain considerable quantities of argillaceous iron-stones, which scale in concentric layers.

The exact quantity of iron ore in this deposit I had not as good an opportunity of determining, but judging from the disintegrated rubbish thrown out from an old trench, formerly made in these shales, apparently in search of coal, I am led to believe that they contain a quantity which might justify the expense of working.

Besides these deposits of iron-stones above cited, there are other shaly spaces that deserve attention for the iron ores which they may furnish. I would refer here, especially, to the following:

The thirty or forty feet of shale overlying the main five-foot coal, and the three or four feet of shale beds beneath the under clay of the same coal.

The shales superimposed on the white and pink sandstones overlying the two and a half-foot or Well coal.

The shales underlying the four-foot coal.

The shales at the base of the Finnie Bluff, and behind the Finnie old field.

At some localities, where good sections are exposed, of shales which lie midway between the three-foot, or 'Little Vein,' and the sandstones underlying the two and a half-foot, or Well coal, I have found five regular bands of calcareous iron-stones, varying from two to six inches, having a specific gravity of 3.61, and containing by analysis—

| | | |
|---|---|---|
| Water, - - - - - - | 7.0 | |
| Bituminous matter, - - - | 0.8 | |
| Insoluble silicates, - - - | 22.0 | |
| Carbonic acid, - - - - - | 23.95 | |
| Protoxide of iron, - - - | 35.37 | —27.514 metalic iron. |
| Magnesia, - - - - - | 5.80 | |
| Lime, - - - - - - | 3.00 | |
| Alumina, - - - - - | 2.00 | |
| Phosphoric acid, a trace. | | |
| Loss and alkalies not determined, | 0.08 | |
| | 100.00 | |

In a space of twelve to fourteen feet, these bands of iron ore amount in all to from fourteen to seventeen inches in thickness.

In the same geological position, in Union county, no regular formation of band ore has yet been found, only ball ore of a different character, sparsely disseminated.

The Lower Coal Measures, in Muhlenburg and Hopkins counties, include important beds of iron ore, some of which belong to the family of the Limonites, or brown and yellow hydrated oxydes, see Nos. 145, 146, and 147, from Muhlenburg county; Nos. 130 and 131, from Hopkins county, in Dr. Peter's Report. Others, referable to the bituminous carbonates of iron, or black band ore, see Nos. 148, 149, 150, 151, and 152, in Muhlenburg, and No. 134, in Hopkins county, also in Dr. Peter's Report.

The chemical investigations which have been made, both by Dr. Peter and myself, in regard to the black band ore, prove that it is only those specimens which have a specific gravity of 2.9 to 3. and upwards, and present alternate layers of black and brown, or reddish grey colors, that can be considered productive. Several samples from Hopkins county, having much the external aspect of black band, but possessing only a specific gravity of from 2.56 to 2.71, and of uniform black, or greyish black color, yielded only from six to seven per cent. of metalic iron, while they contain from forty to seventy per cent. of carbonate of lime. This is, in fact, a bituminous ferruginous limestone, which replaces, locally, the black band ore. It is, therefore, only those specimens that are three times as heavy as water, or more, that can be considered productive.

In the Upper Coal Measures considerable quantities of carbonate of iron are interstratified in the shales overlying the thirteen-inch coal, near low water mark, at Coal Haven, and the head of French Island.

I think it highly probable that several of the shaly spaces, occurring in the next one hundred feet below this geological horizon, may yield bodies of iron ore, but no favorable sections of this space have yet presented themselves from which to form any satisfactory conclusions in confirmation of this opinion.

Three feet of iron ore is reported near the top of the shaft sunk by Mr. Kurzeman, at Williams' Landing, on Green river, under a limestone; and three feet of shale, with argillaceous iron ore under limestone, occurs at Daviess' Ridge, in the forks of Cypress creek and Pond river, in the northern corner of Muhlenburg county.

Along that portion of the southwestern coal field bordering on the Ohio river, the upper four hundred feet of the Coal Measures afford the greatest quantities of limestone. From four to six different beds intervene in this space; one of the highest of these is the Carthage limestone, which crops out in the bank of the Ohio river, one mile below Uniontown, where it is about eight feet thick; another bed, of six or seven feet in thickness, appears about eighty (80) feet above low water, opposite Diamond Island. An eight-foot bed of limestone lies in the hills of Green river, towards its mouth, some seventy (70) to eighty (80) feet above the four-foot coal of Lock and Dam No. 1.

Four other beds of limestone, of three feet eleven inches, seven feet, five feet six inches, and twenty-eight feet eleven inches, are reported in a space of one hundred and eighty-five (185) feet, in the Riddle and Houston borings, of Union county, opposite Wabash Island; the highest of these lying one hundred and fifty-two feet below the Carthage limestone, all of which probably intervene between that limestone and the Diamond Island limestone, besides a seven-foot limestone, at the bottom of the Berry & McGinnis boring, on Highland creek. Many of these limestones will, no doubt, be found to extend only over limited areas.

The lower nine hundred (900) feet of the Coal Measures only afford two limestones worthy of note, immediately on the Ohio river, viz: one bed of about four feet, lying twenty-five feet under the Curlew coal; one over the first coal under the Anvil Rock; but this bed, though prevalent at many localities on the Illinois side, has, as yet, not been detected on the Kentucky shore. Seventeen miles from the Ohio river, up Tradewater, the middle or second coal under the Anvil sandstone, has limestone both above and below it.

The Lower *Southern* Coal Measures are richer in limestones than its *South-western* equivalents.

The seven-foot coal of Hopkins and Muhlenburg counties has generally a heavy, dark bituminous limestone, of two to three feet, overlying it; especially on the waters of Clear creek and Pond river.

On Captain Wing's lot, at Greenville, there is a refractory variegated brecciated limestone, of seven to eight feet thick, and a similar, and probably equivalent limestone, two to three feet in thickness, occurs above the iron ore and shale, in Daviess' ridge, and also at Williams' Landing.

The two and a half-foot coal, of Hopkins county, lying near the base of Wright's mountain, is locally overlaid by dark ferruginous limestone, capable of receiving a good polish. Indeed, several of the above mentioned vaiiegated and black limestones will probably afford good marbles, but time has not permitted me, as yet, to test their polishing properties.

Almost every bed of coal reposes on a bed of fire-clay, not always, however, of the same quality and composition—some being much more silicious than others. Many of them, however, will probably prove to be infusible and valuable for the manufacture of fire-brick, lining furnaces, and making the saggers used by the potters.

These under-clays very generally afford remains of *stigmaria ficoides*.

The roof of many of the coal beds is black bituminous shale, often affording fossil, *ferns*, *Lepidodendron*, *Sigillaria*, and other remains of extinct carboniferous plants. Many of these will probably be found to contain, when analyzed, similar oil from which M. Laurent prepared *Amphelin*. The pyritiferous varieties can also be employed for the manufacture of (copperas) sulphate of the protoxide of iron, and the double sulphate of alumina and potash (alum.)

The compact slaty varieties of coal, like the Breckinridge Cannel coal, yielding about sixty per cent. of volatile matter; also, Parrot coal, and even bituminous shales, afford a vegetable tar, or thick crude oil, from which two products can be obtained; one of an oily consistence, which may be clarified into a nearly colorless oil, that may be substituted, for certain purposes, for other more expensive animal and vegetable oils; the other a transparent, scaly, crystaline substance, of a white color and waxy lustre, which melts at 110° into a transparent oil, at a still higher temperature takes fire and burns with a white flame, without smoke, and leaves no residue. This substance was called by the discoverer, M. Reichenbach, of Blansko, *Paraffin*, from its little tendency to combine with other bodies.

It is supposed that the Breckinridge coal may yield twenty-five (25) per cent. of refined oil, and eighteen (18) per cent. of paraffin.

Some of the impure pyritiferous shaly coal, which has hitherto been regarded as worthless, may possibly be employed economically in the manufacture of bi-sulphuret of carbon, a very volatile substance, which it seems probable may be applied, in connection with steam, for the propulsion of machinery; reducing greatly not only the size of boiler, but the amount of fuel required to produce a given mechanical effect.

Many of the sandstones of the Coal Measures afford excellent freestones for building purposes. I would here cite particularly the mass superimposed on the grey shales and shaly sandstones that overlie the Bell coal, to which the mass of the Finnie bluff also belongs; to the Anvil sandstone; to the fifteen feet of sandstone lying thirty feet above the bottom of Highland creek; to the sandstones of Daviess' ridge, in the forks of Cypress creek and Pond river; and the sandstone which occurs eighty (80) feet above the main Hawesville coal.

There is but one workable bed of coal under the Caseyville conglomerate. Its greatest thickness is at the Union mine, in Livingston county, where it reaches twenty-eight inches; but, on the south side of Tradewater, it undulates between heavy ledges of hard, quartzose sandstone, pinched in the distance of a few yards from one foot seven inches to one foot four inches.

Two or three seams of coal of a few inches in thickness occur, interstratified in the Millstone grit; but no others of any practical value have as yet been discovered under the conglomerate of the *south-western* coal field.

The Millstone grit affords excellent quarries of durable building stone, often very evenly and uniformly bedded, and of good colors. It is also from this formation that the best hearth-stones for iron furnaces have been obtained in South-western Kentucky; that which is free from oxide of iron and lime, and composed of pure grains of quartz, cemented by a silicious paste being preferred.

Four soils have been analyzed by Dr. Peter, from the Coal Measures; one of these, No. 126, from Henderson county, though resting on the carboniferous strata, partakes more of the character of the quaternary loams, and has been already spoken of under that head; the others are No. 10, No. 138, and No. 155, of Dr. Peter's Report. They are essentially of a silicious character, containing from eighty-six and a half (86½) to ninety (90) per cent. of silica and insoluble silicates. No. 10 contains a large amount of alkalies, viz: 0.286 potash and 0.087 soda, or 0.373 of these two alkalies combined, which is more than one-tenth more than was found by Dr. Peter in the rich Fayette soil, No. 27; but it contains much less carbonate and phosphate of lime, and less than half the quantity of organic matter. The porous character of thin, silicious, carboniferous soils, compared with that of the limestone soils of the Blue-grass country, permits the organic matter to be carried by infiltration into the sub-soil; hence the great benefit to be derived by *deep* sub-soil ploughing, especially when the sub-soil is argillaceous or argillo-calcareous. Nos. 138 and 155, of Hopkins county, are rather more retentive in their character, and hence somewhat richer in organic matter; but, being deficient in alkalies and carbonate of lime, they are not as fertile soils as No. 10, and would be much improved by liming and by spreading the ashes of the consumed log heaps over the land. Guano and bone earth would also be of great service to such soils; the stiff, marly earths interstratified amongst the limestone of the adjacent counties of Russell, Todd, Christian, Caldwell, and Crittenden. would be of immense benefit applied to such soils, especially in connection with a clover fallow. So also would the fat marls intercalated with the blue limestone formation; but these being less accessible are hardly available at the present time.

The region of the Millstone grit is not as favorable for agriculture as the adjacent Coal Measures and Barren limestone formation. The soil is usually thin and silicious, and the surface hilly and broken. Where not too abrupt it is capable, however, of producing five-eighths the amount of grain raised on the Coal Measure soils. And the dogwood and hickory lands of the Millstone grit yield very fine crops of silky tobacco.

No chemical analyses have yet been completed of Millstone grit soils. When these are made they will, no doubt, throw light on the best means of improving the virgin soils, and reclaiming those that have been worn out.

The approximate boundary of the Eastern coal field may be thus defined: commencing with the spurs of Poplar chalybeate mountain, in Clinton county, where it throws off its outliers into Tennessee, it takes a north-east course, through Wayne, by the Wallace mountain and Sloan's hill, to near the shoals of the Cumberland river, in Pulaski county; thence to the Big Narrows, of Rockcastle river; thence up the valley of that stream nearly along the confines of Laurel and Rockcastle counties to where these corner with Madison and Estill; thence to where Contrary creek empties into the Kentucky river, three miles below its three forks; thence with a north-easterly course through Morgan and Carter*, towards the head-waters of Tygert; thence down the valley of Tygert to near its confluence with the Ohio river.

The boundary of this coal field is, however, by no means a straight line; on the contrary, it has a very tortuous course, throwing off innumerable spurs; hence, its outline can be defined, in all its meanders, only after the outline of the hills has been defined by accurate topographical maps.

Less is known, at present, of the individual members of this than of the South-western coal field. The best sections which have been obtained, as yet, in this coal field, are in Greenup, Lawrence, Pulaski, and Owsley counties.

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* My examinations in Morgan and Carter counties have as yet been limited to the south-east part of the former and the northern part of the latter, so that I am not as yet able to give any precise information in regard to the boundary in these counties.

In this coal field the measures admit of three sub-divisions, Upper, Middle, and Lower; the first and last divisions containing the most valuable and thickest coal beds, and the latter being remarkably rich in ores of iron, especially in Greenup county.

The general dip of the Coal Measures of the Eastern coal field is about south south-east, or at right angles to the range of the Pine mountain. This mountain chain, which ranges from the Shillalies, near the Tennessee line, and the southern part of Whitley county, near the confluence of Mud and Clear creeks, in a north north-east course, through Harlan county, to the War Gap, and thence to the Sounding Gap, at the corner of Letcher and Pike counties, has been produced by a great dislocation of the Coal Measures, with a nearly uniform bearing, which has heaved the sub-carboniferous limestone more than five hundred (500) feet up in the Pine mountain; thus dividing the Eastern coal field, by a vast longitudinal fault, into two zones; one lying to the north-west of this mountain range, the other to the south-east. The former of these belts, though wider in Kentucky, has a less elevation than the latter, which rises, in fact, to a greater height than the Pine mountain itself—being at least two thousand (2,000) feet above the general drainage of the country, and constituting the range of the Log mountain and the Big and Little Black mountains, skirting along the Tennessee line.

Sect. No. 2 will convey a general idea of the structure of this coal field between the zone of sub-carboniferous limestone, on the north-west, and the Log and Black mountain range, on the south-east.

As yet I am able to give approximate sections only of the three sub-divisions of the Eastern coal field.

The best exposures which I have seen of the upper division, are on Big Sandy, in Lawrence county, above the mouth of its Louisa fork; and in Floyd county, in the vicinity of Prestonsburg.

In the former of these counties, south of Louisa, in a space of about three hundred and fifty (350) feet, from the bed of Big Sandy, I find from six to seven beds of coal; one near low water, supposed to be about two feet thick; one near high water, or from forty to fifty feet above the first, and from three to four feet thick; a third bed about sixty feet higher in the hills, two feet to two and a half thick. There is also said to be a twenty-inch bed about midway of the space between the two last coals, i. e. thirty feet under the last mentioned bed. A fourth bed, about fifty (50) feet above the third bed, equivalent to the middle Gavit coal, which is four feet two inches, with a clay parting of one to three inches, eight inches from the top of the coal. A fifth thin bed, about fifty feet higher than the upper Gavit bed, which is from three and a half to four feet thick; a sixth, or Cannel coal bed, situated about one hundred and forty (140) to one hundred and fifty (150) feet above the fourth, and within fifty (50) to one hundred (100) feet of the top of the hills; of this latter bed I did not have an opportunity of seeing the outcrop, but have reason to believe, from the statements of several of the inhabitants of Lawrence county, that it exists, but probably not of workable thickness.

At Mellenburg, or the Peach Orchard coal mines, on Big Sandy, but one main coal has been opened at an elevation of two hundred and two (202) feet above low water of Big Sandy, with two thin coals under it—one at thirty (30) feet above low water, and the other from seventy-five (75) to eighty (80) feet above low water, or forty-five (45) to fifty (50) feet above the lower bed.

Though the whole height of the hills on this part of Big Sandy is six hundred (600) feet, no openings have yet been discovered above the main bed, but I am inclined to believe, from what I have seen elsewhere in Lawrence county, that by a proper search some might be found, and perhaps of practical value.

In Johnson and Floyd counties there seem to be five to six beds of coal, the main bed lying in the vicinity of Prestonsburg, about seventy-five (75) or eighty (80) feet above the bed of Big Sandy.

Two feet above the bed of the river, at the Northern Kentucky mines, there is a six-inch coal; at forty-five feet a three-foot coal, separated by four feet six inches of black shale from a two-inch coal, above the shale. A compact splint coal, varying from three feet four to two feet eight inches, occurs at an elevation of two hundred feet above low water, opposite the town of Prestonsburg. This is the fifth coal in the series of the Prestonsburg hills, which must lie from thirty to fifty feet above the main coal. Two thin beds of coal seem to occur still higher in the hills; one about one and a half feet, one hundred feet above the five-foot coal, and a top hill seam, the distance and thickness not known.

In Clay county, near the level of high water in Goose creek, a bed of coal occurs, from three and a half to four and a half feet in thickness, which supplies the saltworks, south of Manchester, with the fuel consumed at the various saltworks on that stream. For a space of about two hundred feet above this are shales and shaly sandstones, where a bed of coal of about twenty-eight inches comes in, then a space of about fifteen feet, succeeded by a coal of fourteen inches; then a space of ten feet, surmounted by a ten-inch coal; then a space of one hundred to one hundred and fifty feet, where no coal has yet been detected, when a fourteen-inch coal sets in.

These Coal Measures of the Goose Creek hills belong, probably, in the descending series, beneath the previously described strata of Big Sandy hills, in Floyd county.

Borings have been put down six hundred (600) feet below the main or lowest of these coals above high water of Goose creek, chiefly through shales, schistose and dark argillaceous porous sandstone, with some thin bedded hard sandstones about midway of the borings. These are the muriatiferous rocks of the Coal Measures of Clay, Perry, and Breathitt counties, containing more or less salt.

At a depth of one hundred and twenty feet below Goose creek, a brine was obtained of 6°, or affording six to seven-tenths of a pound of salt to the gallon; at a depth of from two hundred and forty (240) to three hundred (300) feet, water was reached of 15°, i. e. containing a little over one and a half pounds of salt to the gallon. After about three years this brine began to fail. The borings were then carried to the depth of from five hundred and fifteen (515) to five hundred and fifty (550) feet, when water of 15° was again reached, and this is the water which still supplies the principal works, and has been found more permanently strong than at any depth either above or below it; since borings have been carried by Col. Garrard to one thousand feet, without finding any water as profitable to work as that obtained at five hundred and fifteen (515) feet.

The rock in which this water is obtained is a dark grey argillaceous or mud sandstone, with imperfect streaks of coal disseminated, and containing fossil wood converted into carbonaceous matter. I could not learn that any thick workable coals were bored through in the six hundred feet beneath the level of Goose creek, but no strict account was kept of the various materials passed through; neither is it known, for the same reason, whether any valuable coal was passed through in the five hundred (500) feet bored through beneath the productive salt rock of the Goose creek salt basin.

The salt bearing rocks of Goose creek valley appear to be cotemporaneous with the strata intervening between the Ice-House coal and the Caseyville bluff of the south-western coal field, in Union county, but greatly increased in thickness, being at least five or six times as thick.

Next in succession follow the conglomerate associated with the shales and coals of the shoals of the Cumberland river, the cliffs of Rockcastle river, and the sandstones, shales, and coals at the Three Forks of the Kentucky river, between Proctor and the mouth of Contrary creek, in Owsley county.

In treating of the Lower Coal Measures of the south-western coal field, I have already alluded to the fact that the conglomerate marks the limits of the best and most productive of the Lower Coals. This law will not apply, however, to the Coal Measures of Pulaski and Rockcastle counties, since the main coal of Pulaski county, which has been opened above the shoals of the Cumberland river, varying from four to five feet, lies forty (40) feet under conglomerate sandstone, and yields a coal of excellent quality. Sixty feet below this coal is another coal from two and a half to three feet, with an intermediate thin bed of from six inches to one foot, forty-five (45) feet above the latter.

The coals lie from ninety to one hundred and fifty feet above the sub-carboniferous limestone of Pulaski county, and between it and the conglomerate. It appears, therefore, that the carboniferous flora flourished in greater luxuriance at the commencement of the epoch, in the eastern coal field than in the south-west; or else, that the first coal beds and associate strata suffered less from denudation, whilst the currents were established that swept in the pebbles and sand that went to form the conglomerate.

Be this as it may, a knowledge of the fact of the existence of one bed, at least, of good workable coal, one hundred and forty-eight (148) feet above the sub-carboniferous limestone, and forty (40) feet under the conglomerate of Pulaski county, is of great practical importance to the inhabitants of the mountain counties of Kentucky. The entire thickness of the carboniferous rocks of the Eastern coal field cannot yet be stated with accuracy, but it will probably not fall short of two thousand five hundred (2,500) or three thousand (3,000) feet.

The following are the analyses of some of the most important coals of this coal field, which have come under observation up to the present time. See also Nos. 6, 15, 16, 17, 18, 43, 90, 91, 101, 102, 123, 159, and 160, in Dr. Peter's Report.

*No.* 170. *Analysis of the bottom part of the Main Peach Orchard coal, Lawrence county, Kentucky.*

| | | |
|---|---|---|
| Specific gravity, | 1.279 | |
| Total volatile matter, | | 38.6 |
| Coke, (bright solid and coherent,) | | 61.4 |
| | | 100.0 |
| **Moisture,** | 5.00 | |
| **Volatile combustible matter,** | 33.60 | |
| **Fixed carbon,** | 58.55 | |
| **Ashes, (white,)** | 2.85 | |
| | 100.00 | |

*Analysis of the Main Ashland coal—portion taken below the clay parting, Greenup county, Ky.*

| | | |
|---|---|---|
| Specific gravity, | 1.335 | |
| Total volatile matter, | | 44.1 |
| Coke, (puffs up but slightly,) | | 55.9 |
| | | 100.0 |
| **Moisture,** | 7.0 | |
| **Volatile combustible matter,** | 37.1 | |
| **Fixed carbon,** | 51.4 | |
| **Ashes, (reddish grey,)** | 4.5 | |
| | 100.0 | |

*No.* 177. *Analysis of Crawford's Cannel coal, near Grayson, Carter county, Ky.*

| | | |
|---|---|---|
| Specific gravity, | 1.216 | |
| Total volatile matter, | | 59.0 |
| Coke, (unchanged in form,) | | 41.0 |
| | | 100.0 |
| **Moisture,** | 2.0 | |
| **Volatile combustible matter,** | 57.0 | |
| **Fixed carbon,** | 34.5 | |
| **Ashes, (flesh color,)** | 6.5 | |
| | 100.0 | |

*No.* 180. *Analysis of Gavit's Main coal, Big Sandy, five mile shoal, Lawrence county, Ky.*

| | | |
|---|---|---|
| Specific gravity, | 1.306 | |
| Total volatile matter, | | 41.2 |
| Coke, (swells very much,) | | 58.8 |
| | | 100.0 |
| Moisture, | 4.5 | |
| Volatile combustible matter, | 36.7 | |
| Fixed carbon, | 53.8 | |
| Ashes, (light grey,) | 5.0 | |
| | 100.0 | |

*No.* 181. *Analysis of McHenry's coal, Tugg Fork of Big Sandy, Lawrence county, Ky.*

| | | |
|---|---|---|
| Specific gravity, | 1.313 | |
| Total volatile matter, | | 40.0 |
| Coke, (swells very much,) | | 60.0 |
| | | 100.0 |
| Moisture, | 3.0 | |
| Volatile combustible matter, | 37.0 | |
| Fixed carbon, | 50.0 | |
| Ashes, (whitish grey,) | 10.0 | |
| | 100.0 | |

*No.* 204. *Analysis of Aron's & Boggs' coal—Big Sandy Coal and Mining Company, edge of Floyd and Johnson counties, Ky.*

| | | |
|---|---|---|
| Total volatile matter, | | 35.2 |
| Coke, (compact, did not swell up,) | | 64.8 |
| | | 100.0 |
| Moisture, | 3.0 | |
| Volatile combustible matter, | 32.2 | |
| Fixed carbon, | 63.8 | |
| Ashes, (flesh colored,) | 1.0 | |
| | 100.0 | |

To give a full and complete insight into the chemical constitution of the coals of Kentucky, an ultimate analysis is required in addition to the proximate chemical analysis, showing not only the total quantity of carbon, both in coke and volatile matter, but the proportion of oxygen, hydrogen, and carbon; this kind of analysis is especially required for coals to be used for illuminating purposes. As yet time has only permitted of the ultimate analysis of one coal, No. 159, from the Three Forks of the Kentucky river. For the same reason we have not been able to give an exposition of the constituents of the ashes, which is also desirable, to be able to judge of their fusibility, on which property depends their disposition to form clinker.

It will be perceived, from the proximate chemical analysis, that many of these coals, of the eastern coal field, are of superior quality —equal or superior to the best Pittsburg. The best of the Big Sandy coals contain several per cent. less ashes, and more fixed carbon, than the Youghiogheny coal. The screenings from those coals which are richest in fixed carbon, and at the same time freest from sulphur, will bring from seven to eight cents per bushel in Cincinnati, where it is found nearly as good for generating steam as the lump coal of many mines.

The spaces between the coals of the eastern basin are not yet sufficiently well known to enable me to pronounce upon the law of their relative distances, but it appears probable that here, also, a great uniformity will be found.

The eastern coal field is vastly rich in iron-stones, especially towards its base, in Greenup and Carter counties. Fifty-eight (58) ores have been analyzed, from Greenup county, and six from Carter; also, thirteen different specimens of pig-iron, produced from these ores, and fifteen furnace slags. These ores are all interstratified as beds conformable to the associated Coal Measures.

Their relative position is well illustrated by local sections, obtained at the ore-banks of the Sandy, Mt. Savage, Star, Bellefonte, Pennsylvania, and Amanda Furnaces, which will be found in the second chapter, under the head of Greenup county.* See Diagram No. 3.

The beds vary from three inches to four or five feet. They belong, mineralogically, to the family of limonites, or hydrated oxydes, and proto-carbonates of iron, yielding from twenty-seven to sixty per cent. of metallic iron. They lie usually on or between shaly beds, sometimes resting on or overlaid by limestone.

These associated limestones are often highly ferruginous, yielding from seven as high as twenty-five per cent. of metallic iron, therefore well adapted for fluxes for the iron-ores, when free from pyrites or other injurious principles, since they not only supply the lime necessary to produce, with the earthy ingredients, the proper cinder or furnace slags, but contribute largely to the iron product.

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*For further remarks on this subject, see second chapter.

The chemical analyses of certain ores discarded as impracticable, especially of Nos. 36, 37, and 38, prove that their impracticability does not arise from the presence of unusual quantities of injurious elements, such as sulphur, phosphorus, arsenic, or zinc, since they contain but a trace of sulphur, 0.15 per cent. being the largest amount of that substance estimated in any of them, and 0.3 per cent. of phosphorus, while no appreciable quantity of either arsenic or zinc was detected. Indeed it seems that the difficulties which have been encountered in reducing these ores arise from their very richness, containing, as they do, from sixty and nine-tenths (60.9) to thirty-nine and four-tenths (39.4) per cent. of metallic iron, and only from 3.47 to 9.47 of insoluble silicates, while ores highly esteemed contain but twenty-nine (29) per cent. of iron, and forty-five (45) per cent. of insoluble silicates.

It appears, therefore, that all that is necessary to render these ores available is the addition of earthy matter, either by mixing them with lean ores, so as to reduce the per centage of iron, and increase the quantity of silicious earths, or to introduce, with the rich ore, a certain quantity of ferruginous shale to the furnace burden. As this material is abundant throughout the iron region of Greenup county, often constituting the stripping of the ore-banks, it can be easily obtained and applied for this purpose, where suitable mixtures of lean ores cannot be had.

The object to be obtained by these corrections is to insure the formation of a fluid slag or lava, that will flow freely, eliminate completely the metal, admit of its free carbonization, and thus increase the fusibility of the pig-iron.

Furnace slag being the index to the quality of the iron simultaneously produced, I selected, during my geological reconnoissance of Greenup county, various specimens of these glassy scoriæ from different iron works, with special reference to the quality of the cast-iron flowing from the furnace at the time of their production.

The general results obtained by their chemical examination are as follows: The principal constituents are silica, lime, and alumina, with small quantities of magnesia, potash, soda, and sometimes protoxide of iron and manganese.

The normal quantity of silica is about fifty-six (56), lime twenty (20), alumina fifteen and five-tenths (15.5), other bases eight and five-tenths (8.5) per cent.

The silica ranges froma bout fifty (50) to sixty (60) per cent.; the lime from thirteen (13) to twenty-seven (27); the alumina from eleven and five-tenths (11.5) to twenty (20); the other bases from five to eleven.

The glassy slags having, usually, a smoky purple color, produced when the furnace is making soft grey iron, contain very nearly the average or normal quantity of silica—fifty-six (56) per cent.—with generally nearly the largest amount of lime. The opaque pea-green slag, No. 86, produced at the Raccoon furnace, contains the largest amount of silica, sixty-one (61) per cent. This was the least fusible of all the slags operated on, and contained very nearly three per cent. of protoxide of iron. The white pumiciform slag contains the smallest quantity of silica, and the largest quantity of lime, and is the most fusible of all. Its extreme lightness and cellular structure are no doubt attributable to its fusibility, and the tendency which the excess of lime has to remove sulphur and phosphorus, which, being disengaged suddenly in the form of sulphuretted and phosphuretted hydrogen, in the midst of or underneath this fusible slag, puffs it up into the porous white cinder, which is not only remarkable for its extreme whiteness and lightness, but for the length of time it continues to disengage sulphuretted hydrogen, with a crackling sound, even for months after its removal from the furnace.

This pumicifrom slag has very nearly the same chemical constitution as the an-hydrous prehnite, analyzed by Jackson and Whitney.

The lime in this slag is considerably more than is required to flux the earthy ingredients; if the ore has a considerable amount of sulphur or phosphorus, then the predominance of lime may, perhaps, be found advantageous in removing the excess of these elements.

The pea-green slag, No. 66, contains six per cent. of protoxide of iron, equivalent to four and six-tenths (4.6) per cent. of metallic iron; the largest amount of iron in any of the slags analyzed. This loss of iron might be avoided, in part at least, by increasing the amount of lime about three per cent. to replace the protoxide of iron.

No. 52 contains the largest quantity of alumina. This is no doubt to be accounted for from the fact that the carbonate of iron—"grey limestone ore," No. 49, worked at the Bellefonte furnace, where this slag was obtained—contains a larger quantity of alumina than any of the ores from which the slags analyzed have been derived. It does not appear, however, that the pig-iron from this furnace contains more than the average quantity of alumina.

It is important to remark, that though the quantity of lime, alumina, and other bases, are liable to some little variation, even in the best slags—Nos. 40, 64, 65, 85, and 110—yet they all possess this chemical relation in common, as is shown by Dr. Peter's Report, that the quantity of oxygen in these bases is, within a fraction of a per cent., one half the oxygen contained in the associated silica or silicic acid; in other words, all these slags are *bi-silicates*, proving that there is no better mode of ascertaining whether the ore and flux are duly proportioned in the burden of the furnace, than by a chemical analysis of the slag.

The pea-green slag, No. 112, produced at the New Hampshire furnace, preserves this normal *proportion* of oxygen in the bases and silica, though it produces a pig-iron of rather closer texture than usual; this may, perhaps, be accounted for from the manganese, which is nearly three per cent., or over two per cent., above the average quantity, and about one and a half per cent. more than in any other slag on the analyzed list. This is no doubt derived from the very dark brown red limonite ore, No. 106, worked at the New Hampshire furnace, which contains 2.15 per cent. oxide of manganese, being the largest proportion of that oxide present in any of the ores analyzed, except No. 44, the "Black Vein," of the Buena Vista ore banks, which has 2.92; No. 57, the dark brown red "Little Block ore," of the Buffalo ore banks, which has 3.15; No. 119, the top hill ore of the Clinton furnace, which has 2.17; and No. 11, Wallace's iron ore, from near the Falls of Blain, which has 3.41. It would require, however, a greater number of comparative analyses of ores, pig-iron, and slags, to be able to draw correct conclusions on this subject, especially as pig-irons Nos. 113 and 114, cast at the New Hampshire furnace, do not contain more than an average amount of manganese.

A few general remarks on the chemical composition of the various specimens of pig-iron analyzed, may be useful: No. 89 contains the largest quantity of silica, 6.88, which has evidently an injurious effect on the quality of the iron, as it is particularly noted that when such iron is produced the furnace is working stiff, the iron is "*high*," and no doubt has *cold short* properties. This could easily be corrected by increasing the quantity of limestone flux, until the cinder flows free, and assumes the appearance and composition of the true bi-silicate. This iron also contains the largest amount of manganese, 0.63. No. 114 contains the largest amount of phosphorus, 1.4, and the largest but one of aluminium, 0.44, and the largest amount of graphite, 3.13. per cent. It is singular that though this pig-iron is light colored, and fine-grained, it is yet comparatively soft.*

The same remarks will apply, in a great measure, to No. 113, which contains only 0.08 more aluminium, and 0.1 less phosphorus, 0.3 less graphite than the preceeding.

The largest amount of free carbon was found in No. 48, a soft grey pig-iron of a fine grain.

The largest quantity of slag, 0.93 per cent., was obtained from No. 87, a soft but rather brittle iron. This iron also contains a large proportion of silica, 5.13, being only 1.75 less than No. 89, as well as a large amount of manganese, 0.59, which is only 0.04 less than No. 89.

No. 42 contains the largest quantity of magnesium, and is a moderately fine-grained soft grey cast-iron.

No. 113 contains the largest amount of alkaline bases, viz: 0.33 potassium, and 0.21 of sodium.

Since the Greenup county impracticable ores are so rich in iron, and four feet in thickness, their successful reduction in the furnace becomes a matter of great practical importance, not only to the owners of ore banks but to the state of Kentucky.

I would here also call the attention of iron-masters to the variable composition of the limestones used as fluxes at the different iron establishments in Greenup county—see Nos. 39, 51, 62, 63, 77, 84, 108, and 109, of Dr. Peter's Report. The amount of insoluble silicates, ranging from a half to thirty per cent., showing the importance of a knowledge of the chemical composition of the limestones, as well as the ores, in adjusting the proportions of each. The composition of the limestone selected should always have relation to the composition of the ore to be fluxed; for example, though a limestone like No. 84, containing thirty per cent. of insoluble silicates, might be appropriated for ores defficient in silicious earths, like Nos. 36 and 38, it would be altogether inappropriate for ores similar to specimens Nos. 31, 32, 50, 54, 57, 69, 72, 80, 84, 94, 103, and 105, with which it would undoubtedly produce an iron having decidedly cold-short properties.

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* See Dr. Peter's Report for further remarks on this subject.

When a limestone is used for flux containing large quantities of iron, as for instance, No. 76, which yields 13.19 per cent. of carbonate of iron, and 1.56 per cent. of oxide of iron, it is necessary to use it in larger quantities than if it were a purer limestone, with merely a fraction of a per cent. of iron, otherwise it will not afford the necessary quantity of lime to form the model cinder.

Such a limestone should add six to seven per cent. of iron to the furnace runs.

When it is desired to avoid making a white and brittle iron, limestone, as well as ores containing more than one or two-tenths of a per cent. of phosphorus, should be avoided, since experience seems to prove that the presence of even half a per cent. of phosphorus in iron is sufficient to diminish its tenacity; though pig-iron produced from certain bog ores has been found to contain five and a half per cent. of phosphorus. Such iron is generally white and brittle. It is to be remarked, however, that some pig-iron which contains from four to six per cent. of graphite and chemically combined carbon, may contain one to one and a half per cent. of phosphorus, and yet be grey iron.

Half a per cent. of sulphur in pig-iron does not appear materially to diminish the tenacity of the iron; it is even contended by some chemists that quantities of that element, under four-tenths of a per cent., rather increase its firmness. It is a well established fact, however, that two to three per cent. of sulphur is very destructive to the qualities of pig-iron, rendering it white, brittle, and porous, expelling, at the same time, the chemically combined carbon, required to be present in the composition of good grey iron. It is true, also, that sulphur, to a certain extent, may render iron more fusible, and therefore might even be desirable to the amount, say of one or two per cent., in making fine castings, if it had not, at the same time, a tendency to cause the fluid iron to chill suddenly on the surface, before the gases and vapors have escaped from the interior, and thus render the castings porous and imperfect.

When we consider, then, that the qualities of pig-iron may be deteriorated by the presence of even a fraction of a per cent. of certain elements, liable to occur both in ores and limestone, the necessity of an accurate knowledge of the chemical components of these, the most essential ingredients in the production of iron, will be apparent to every manufacturer of this metal; nor can he fail to appreciate the value and importance of the information conveyed by the numerous technical chemical analyses appended to this report, made from suits of ores, limestone, and furnace slags, selected with especial reference to the development of practical results, and the introduction of improvements in the smelting of Kentucky ores.

Below are appended two more analyses of Greenup county ores, and one of cast-iron, in addition to those analyzed by Dr. Peter.

*Analysis of "Speckled Iron Ore," from New Hampshire Furnace, replacing limestone ore, often over chert, then not so good. Greenup county, Kentucky.*

| | | | |
|---|---|---|---|
| | | Silica, | 35.4 |
| Moisture, | 5.110 | Alumina, tinged with iron, | 14.0 |
| Insoluble silicates, | 49.940 | Lime, | 0.3 |
| | | Magnesia, | 0.2 |
| | | | 49.9 |
| Peroxide of iron, | 20.000 | 17.927 per cent. metallic iron. | |
| Protoxide of iron, | 5.040 | | |
| Alumina, | 13.500 | | |
| Magnesia, | .363 | | |
| Soda, | 4.502 | | |
| Potash, | .885 | | |
| Phosphoric acid, | .636 | | |
| Loss, | .024 | | |
| | 100.000 | | |

*Analysis of a variety of calcareous iron-stone, used at Sandy Furnace, without any limestone as flux, Greenup county, Kentucky.*

| | | | |
|---|---|---|---|
| Specific gravity, | 2.8121 | | |
| Moisture, | .270 | | |
| Carbonic acid, | 18.800 | Silica, | 20.6 |
| Insoluble silicates, | 25.600 | Alumina tinged with iron, | 5.0 |
| | | | 25.6 |
| Silica dissolved by hydrochloric acid, | .490 | | |
| Peroxide of iron, | 16.744 | 13.65 metallic iron. | |
| Protoxide of iron, | 2.480 | | |
| Lime, | 21.800 | | |
| Alumina, | 6.500 | | |
| Soda, | 2.500 | | |
| Potash, | .660 | | |
| Magnesia, | .400 | | |
| Phosphoric acid, | .800 | | |
| Sulphur, | .013 | | |
| Loss, | .513 | | |
| | 100.000 | | |

*Analysis of Big Sandy Furnace Pig-Iron, Greenup county, Kentucky.*

| | | |
|---|---|---|
| Metallic iron, | 91.000 | |
| Uncombined carbon, | 2.580 | 6.03 total carbon. |
| Pure graphite, | 3.200 | |
| Carbon extracted by potash, | .250 | |
| Silica, | 1.050 | |
| Phosphorus, | .350 | |
| Chromium, | .147 | |
| Alkalies, | .250 | |
| | 98.827 | |

## SUB-CARBONIFEROUS LIMESTONE.

Descending from the conglomerate and millstone grit, to the main body of the sub-carboniferous limestone of the Barrens of Kentucky, we pass alternations of sandstone, limestone, and marly shales, forming what may be denominated a transition series, marking the passage from the termination of this great calcareous formation, to the sandstone of the millstone grit. During this interval the prevailing sediment was sand, with occasional intercalations of calcareous beds, which, for the most part, are more or less earthy, and marked by an interesting assemblage of the fossil remains of an ancient marine life, in which the delicate, reticulated, lamelliferous corals greatly predominate.

Locally there occurs almost immediately under the conglomerate a great mass of soft grey, greenish, purple, and reddish shales, or marly deposits, which sometimes attain a great thickness; as opposite Millstone Run, and at the Buffalo Wallow, in Hancock county; this is the "*Long Running Rock*" of the Salt Borer.

Two principal calcareous belts are recognizable in the Tradewater zone of this formation, the upper about fifty (50) feet thick, lying between two and three hundred feet below the main mass of the conglomerate; the lower some one hundred and fifty (150) feet thick, lying about one hundred feet below the upper. The former of these is particularly characterized by numerous *Archimedes*,* associated with *Pentremites* and interesting *Crinoidea*.

Both these genera range down, also, into the lower belt, where the *Pentremites* attain their greatest dimensions—one species measures two inches and five-eighths in height, and two and a half inches across the basal plates. Between this calcareous mass and the great body of the sub-carboniferous limestone intervenes about two hundred (200) feet of sandstone, some of which is a very regularly and evenly bedded, close-textured rock, approaching to quartzite in hardness, occasionally impressed with fine specimens of *Lepidodendron*—the even thin-bedded close-textured beds, affording, locally, good whetstones. See Section No. 1.

The eastern belt of this formation, in Breckinridge and Meade counties, is more calcareous, and includes in its upper mass, under the reddish yellow or flesh-colored Archimedes limestone, samples of fine white oolitic limestone, capable of receiving a good polish, and producing a white or cream-colored marble of considerable beauty, especially when inspected under the magnifier.

These limestones also produce a remarkably white lime, that commands ten cents more per bushel than the lime obtained from the associate limestone. These roe-structured limestones seems to have been formed in eddies, where the water circled round in spiral or funnel-shaped currents, which kept particles of fine sand revolving in such a manner that they acquired concentric calcareous coatings, until, having attained the size of fish roe, their gravity was sufficient to overcome the power of suspension of the rotary currents, when they sunk to the bottom.

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*See Table 1, Figure 1.

The geological causes which operated to produce the various modifications which present themselves in different parts of this formation were evidently local, and the beds, subsequent to deposition, seem to have been subject, in some instances, to denudation by temporary currents, whereby extensive excavations were first effected, and, as these currents diminished in force, sediments were transported and filled up the vacancies. Such causes, no doubt, operated to produce the frequent local modifications which are encountered in this formation, both in thickness and lithological character.

The sections which will be found in the second chapter, under the head of Edmonson, Meade, and Breckinridge counties, will amply illustrate the above remarks. In consulting these local sections the reader will also find that a feeble carboniferous flora sprung up during the deposition of some of the upper members of these intercalated subcarboniferous bands; but only for a very limited time; not longer than sufficed to produce from two to ten inches of coal. In Breckinridge county a ten-inch seam of coal is wedged in immediately under the Pentremital limestone, underlying cliffs of heavy sandstone on Shotpouch creek; in Meade county, a streak of two to three inches of coal is associated with purple shales and limestone in the bluffs of the Ohio river between Boonsport and Concordia. See Diagram No. 4.

These unimportant exceptions do not, however, militate against the great and important practical fact that no *workable beds of coal* are found in the western States below the Archimedes and Pentremital limestones. During the twenty years through which I have extended my geological researches over the western States I have, as yet, found no exception to this law, than which no geological fact of greater import presents itself for the guidance of the miner after fossil fuel.

The sub-carboniferous limestone appears to be much thicker on the west side of the basin than on the east. The sections obtained on the Ohio river, between Rock Haven and Cloverport, disclose from four hundred (400) to five hundred (500) feet of sub-carboniferous limestone; in Crittenden county it is, no doubt, more than double that thickness, if we may judge from the continuous dip of the limestone for miles at an angle of 4° or 5°, but as yet we have no reliable data from which to calculate the thickness with precision.

The southern belt of this formation is wonderfully cavernous, especially in its upper beds, which being more argillaceous, and impregnated with earths and alkalies, are disposed to produce salts, which oozing through the pores of the stone, effloresce on its surface, and thus tend to disintegrate and scale it off, independent of the solvent effects of carbonated water. Beneath overhanging ledges of limestone, quantities of fine earthy rubbish can be seen, weathered off from such causes. In these I have detected sulphate of lime, sulphate of magnesia, nitrate of lime, and occasionally sulphate of soda. The tendency which some calcareous rocks have to produce nitrate of lime is, probably, one of the greatest causes of disintegration.

Most extensive subterranean areas have thus been excavated or undermined in Edmonson, Hart, Grayson, Butler, Logan, Todd, Christian, and Trigg. In the vicinity of Green river, in the first of these counties, the known avenues of the Mammoth Cave amount to two hundred and twenty-three (223), the united length of the whole being estimated, by those best acquainted with the Cave, at one hundred and fifty (150) miles; say that the average width and height of these passages amount to seven yards each way, which is perhaps near the truth, this would give upwards of twelve million (12,000,000) cubic yards of cavernous space, which has been excavated through the agency of calcareous waters and atmospheric vicissitudes.

The organic contents of these various limestones serve as the best criterion for their sub-division, especially as such a grouping will coincide, in a great measure, with the physical and agricultural features which each imparts to the country over which they extend.

The upper division is formed by the Archimedes and Pentremital limestones. Where these are associated, as they frequently are, with beds of greenish and grey shales, they give rise to a narrow belt of unproductive gladey land, almost destitute of vegetation. What little timber it supports is usually a scanty growth of scrubby post-oak on the ridges; on the slopes, post-oak, sassafras, shumach, and white oak, with black gum towards the base. The soil is of a stiff marly nature, and must necessarily contain a large amount of argillo-calcareous matter.

Indeed the sterility of the land is probably due to the superabundance of lime and alumina; the former exerting a too powerful solvent effect over its organic contents, and thus exhausting it of these constituents; the latter renders it stiff and refractory, so that it bakes, cracks, and forms extensive slides on the slopes of hills. The seeds of plants, in such soil, are frozen out in winter, super-saturated with moisture in spring, and deprived of the organic matter necessary for their nutriment. In dry weather the ground becomes hard and compact, yet full of fissures, so that the germinating plant has no power to penetrate its way to the surface; or, if already in an advanced state of growth, its roots are laid bare, and the tendrils perhaps torn asunder; yet these stiff calcareous clays, when subdued by cultivation and supplied with organic manures, are capable of returning abundant crops, while they are, as I have already stated elsewhere, materials well adapted for the amelioration of poor silicious soils.

Time has not permitted me to lay before you an analysis of a soil characteristic of this division of the sub-carboniferous formation.

The second division of the sub-carboniferous limestone, in the descending order, comprises the *Lithostrotion* bed, or Barren limestone group; this is characterised by a peculiar reed-like fossil coral, having a prominent central axis which was designated, on this account, by Lesueur, *Stylina*, but described previously by Keyserling under the name of *Lithostrotion*. Almost everywhere throughout the western States, as well as in Kentucky, this sub-division of the limestone, underlying the carboniferous rocks, is marked by abundant remains of this fossil, usually, however, converted into pale yellowish chert of the same composition as the numerous seggregations universally disseminated in the adjacent limestone, somewhat after the manner of flints in the chalk formation; these, resisting the action of solvent and decomposing influences for a longer period than their calcareous matrix, drop out and lie strewed over the surface of the ground.

The limestones of this group vary in color from a light grey or cream-color, to a very dark grey approaching black. They are, for the most part, thicker bedded than the preceding group, and less argillaceous, though they occasionally afford those earthy varieties of conchoidal fractured limestones, which can be manufactured into hydraulic cement. Sometimes they are as compact, close-textured, and fine-grained as the lithographic limestones obtained from the upper

Jura formation of Sohlenhofen, seldom, however, possessing the same uniformity of surface for which these stones are so justly celebrated, and, for this reason, it has hitherto been found difficult to obtain, from our sub-carboniferous limestone, slabs of large dimensions without flaws or imperfections. If regular quarries were opened, in favorable situations, slabs of more uniform quality could be obtained, as all such limestones are liable to be intersected by "dry cracks" at their outcrop.

This limestone group produces, for the most part, an excellent soil, well adapted for the growth of corn, wheat, barley, and certain grasses.

In the early settlement of Kentucky the belt of country over which it extended was shunned, and stamped with the appellation of "*Barrens;*" this arose, in part, from the numerous cherty masses which locally encumbered the ground, in part from the absence of timber over large tracts, and in consequence of the few trees which here and there sprung up, being altogether a stunted growth of black-jack oak, *quercus ferruginea*, red oak, *quercus rubra*, and white oak, *quercus alba*.

The value of the red calcareous soils of the "Barrens" are now beginning to be appreciated, so that lands which formerly were considered hardly worth locating, are now held at twenty-five ($25), thirty ($30), and even as high as fifty ($50) dollars an acre, in the neighborhood of some towns.

At the present time the so called "Barrens" of Kentucky are, to a considerable extent, timbered with the above varieties of oak, black Hickory, and occasionally Butternut, *juglans cathartica*; Black Walnut *juglans nigra;* Dogwood, *cornus florida;* Sugar-tree, *acer saccharinum.*

The old inhabitants of that part of Kentucky all declare that when the country was first settled it was, for the most part, an open prairie district, with hardly a stick of timber sufficient to make a rail, as far as the eye could reach, where now forests exist of trees of medium growth, obstructing entirely the view.

They generally attribute this change to the wild fires which formerly used to sweep over the whole country, in dry seasons, being now, for the most part, avoided or subdued, if by accident they should break out. No timber appears capable of surviving the scorching effects of such fires, but the thick-barked black-jack oak, which, here and there resisting its ravages, stood solitary monuments of its hardy nature, and the blasting influence of the prairie fire.

It is probable, however, that some other influence contributed to suppress the growth of timber in the Barrens of Kentucky, since wild fires were equally liable to occur in the heavy timbered land of adjacent formations. It is altogether probable that there was a peculiar tendency in the soil to produce that luxuriant growth of barren grass which took possession of the soil, to the exclusion of all timber, and which is described as having attained a height of five to six feet. Since the settlement of the country this grass has almost become extinct, whereby opportunity has been afforded for timber to take root and flourish.

Nearly throughout the whole extent of the Barrens of Kentucky numerous conical depressions of the surface are of frequent occurence, known by the name of "*Sink-Holes.*" These prove the cavernous character of the limestones on which the country is based, since these sink-holes have, undoubtedly, originated from the giving way of the roof of subterranean caves. The subsided areas vary in dimensions from twenty yards in diameter to several acres, and are not unfrequently the receptacles of ponds of water, which prove of great convenience to those sections of the country deficient in water.

On account of the great volume of surface-water which sinks through the fissures of the Barren limestone into the vacancies beneath, it is often difficult to reach water by wells of reasonable depth; it is also a very common occurrence, throughout the Barrens, for considerable streams of water to sink abruptly from the surface, which are either "*lost*" or run for many miles under ground before they again find an exit from their subterranean course.

Many of the smaller sink-holes which permit the water to drain away through small rents or fissures at their bottoms, have been rendered impervious by feeding stock constantly in the hollow of the depression. By this means mud and clay are by degrees firmly trodden into the leakages, and these sink-holes thus become, in time, pools fit to water cattle, and serviceable for other farm-yard purposes. Where there is sufficient stock water the filling up of sink-holes with impervious earths, either by accident or design, is objectionable, and should be avoided, as it not unfrequently overflows, in time, valuable tracts of land, but may be the cause of producing intermittent fevers.

Descending from the geological horizon of the Lithostrotion sub-division of the sub-carboniferous formation, to the base of this great limestone formation, there is, for the most part, a tendency to an admixture of argillaceous matter, producing sometimes hydraulic limestones, sometimes argillaceous or shaly and geodiferous limestones, interstratified with subordinate beds of a sub-crystalline texture, some of which are charged with entrochites and reticulated corals; others contain numerous *Spirifer striatus*?

It is possible that this portion of the formation may hereafter admit of a third sub-division under the Lithostrotion beds, but the present state of our knowledge of their paleontology will hardly admit of a satisfactory classification.

The Lithostrotion beds of the sub-carboniferous limestone are the repositories of the extensive deposits of hydrated oxides of iron, which constitute so large a portion of the mineral wealth of Trigg, Lyon, Caldwell, Livingston, and Crittenden counties. In consequence of the loss of a large part of the collection made in these counties, in the wreck of the steamboat Cape May, and a failure in the receipt of several boxes left for shipment at depots on the Cumberland river, I am not able to furnish as complete a report on this iron region as I could have wished.

In Dr. Peter's Report will be found three analyses of ores from this formation—Nos. 139, 142, and 143—showing a yield of metallic iron of from twenty-five to fifty per cent., but as yet there are no comparative analyses of ores, pig-iron, and furnace slags.

In this place I would beg particularly to call the attention of the iron-masters of south-western Kentucky to what I conceive to be the origin and source of this ore. The hints which I have already thrown out on this subject, in my previous communication of last May, have been in a great measure confirmed. If my views on this subject prove to be correct they have a most important practical bearing on the extent, value, and permanency of the yield of the ore beds of south-western Kentucky. Unlike the iron ores of the Coal Measures of Greenup county, these limonites or hematitic brown oxydes of iron never lie in conformable, interstratified beds, but uniformly occupy the slopes of the hills, mixed very irregularly with ferruginous clay and chert, the whole leaning *unconformably* on the out-crop of the ledges of sub-carboniferous limestone, conveying to the mind of the close observer an iron formation produced by infiltration. Though a great uncertainty exists as to the extent of such ore beds, so much so that no experienced iron-master is ever willing to trust implicitly to surface indications, however promising, without fairly opening his ore banks, still such a degree of uniformity is observable in the general bearings of the individual deposits that I have long been led to suspect their connection with regular veins of determinate bearing, traversing the limestone formation of the country.

In Kentucky I was struck with this fact in examining the ore banks in Crittenden and Lyon counties, where I found the deposits ranging N. 18° to 20° E., but I had previously observed this fact in other States, particularly in Calloway county, Missouri, and afterwards in Hardin county, Illinois; and within the last few years I have been able, in several instances, to trace these ores leading into the fissures of the sub-carboniferous limestone, with well defined walls, bearing from N. 15° E. to N. 22° E. and twenty-four to twenty-seven and a half feet apart.

These facts lead me to the belief that these ores of iron, occupying the slopes of hills having a nucleus of sub-carboniferous limestone, had their origin in fissures or lines of fracture of that formation of determinate course and of large dimensions, whence an inexhaustible supply may be obtained if ever the superficial masses fail. I conceive that the deep-seated ores in these veins exist in a more concentrated form, and in a lower state of oxidation than on the surface; that through the solvent powers of highly heated carbonated waters, both oxyde of iron and silica have been forced to the crevice vents and flowed over the declivities. The ferruginous waters losing their carbonic acid, and, at the same time, their solvent power over the protoxide of iron, it was gradually precipitated, and combining with the oxygen of the atmosphere and moisture, it assumed the form of infiltered masses of hydrated oxyde of iron, mixed more or less with silicious earths varying from ten to fifty per cent.; but the principal body of silica, being specifically lighter, seggregated to itself in the form of chert, hornstone, and other flint-like productions, which became heterogeneously disseminated with the most superficial portions of the ore. In its passages over the out-cropping edges of the calcareous bed the chalybeate waters, mingled with debris and talus of the adjacent rocks, permeated the ferruginous clays washed from the crevices, joints, and seams of the limestone. Dripping in vacant spaces, it formed the so called "*pipe ore*," analagous in form though not in composition, to the calcareous stalactite. Oozing through coarse gravelly earths or lumpy clays, they coated some silicious or argillaceous nucleus that intercepted their downward passage; thus was produced the different varieties of "*pot ore*." Percolating through porous earths, the ore assumed the honeycomb structure, in which the interstices are fine and closely set.

It is easy to perceive how ore formed this way, by a process of infiltration, will, on the slopes, be variable in quality and various in structure; and how the quantity must have depended upon the duration of the overflow, the configuration of the surface, and the degree of saturation. But when it can be traced to a parent vein of good dimensions, well filled with ore, the amount to be obtained is almost unlimited.

Immense veins of fluor spar, sometimes fifty feet in width, traverse the south-western belt of the sub-carboniferous formation. Two systems of veins are recognizable; one set having a bearing N. 18° to 21° E., and cross courses running N. 54° to 58° E.; the former of these systems has, therefore, the same course as the veins of iron ore previously noticed.

Both systems of veins afford sulphuret of lead; and the former contains sulphuret of zinc, and probably also sulphuret of antimony.

Attempts have been made to work these veins of argentiferous galena, but hitherto with but partial success. Where I have had an opportunity of inspecting these veins, at the Columbian mines, in Crittenden county, the lead is mixed with large quantities of crystalized blende.

Within the distance which these veins have been penetrated, at this locality, the galena does not appear to have been well concentrated in the vein, and the large amount of zinc materially interfered with the isolation of the lead ore.

The imperfect mining operations which have been instituted in Kentucky in search of galena in this formation, have been, as yet, very superficial, extending only to the depth of forty to sixty feet; and they have been conducted without system or adequate means. Under these circumstances, it is hardly to be expected that such desultory operations could be profitable; unless in a lead region like that of Wisconsin and Iowa, where millions of pounds of galena have been dug from pits not twelve feet in depth.

It is important to observe, in calculating on the practicability of working the lead ores existing in these limestones, that they occur in the same geological position as the most productive lead-bearing limestones in the north of England; that the lead mines of Derbyshire are in a limestone underlying the Millstone grit, as in Crittenden county; and that the sulphuret of lead is accompanied with the same vein-stones. Previous to the discovery of the lead mines of Cumberland, Durham, and Yorkshire, the Derbyshire mines were the most productive in England.

As yet I have not observed any trap or toadstone, either cutting the sub-carboniferous limestones of Kentucky in dykes or insinuated horizontally into the stratification of the beds; the presence of such igneous rocks in the Derbyshire lead region is the only important traceable difference in the otherwise strong analogy existing between the two formations—so far as our researches at present extend.

These lead veins have, as yet, never been followed in Kentucky to a sufficient depth to prove their productiveness; for it is a well known fact that, as a general rule, metallic veins do not prove profitable under several hundred feet from the "*grass*."

The richest argentiferous galenas of this State, which we have tested, up to this time, for the per centage of silver which they contain, have yielded about one part in a thousand, or thirty-two ounces to the ton. Before the introduction of the improved method of extracting silver from lead it was considered that two parts in one thousand were necessary to make it an object of manufacture; but since means have been devised of separating the silver without the necessity of converting the lead into litharge, a yield of but twelve ounces to the ton has been found profitable in countries where fuel and labor are cheap.

At many localities in the range of the sub-carboniferous limestone lead ore has been discovered, but the most favorable situations at present known, judging from analogy, for the development of lead mines in this formation, are in Crittenden and Livingston counties.

The large proportion of peroxide of iron* in the sub-soil reposing on the Barren limestone, renders the lands of this part of Kentucky emphatically red lands. This red sub-soil lies often within a few inches of the surface, so that it is exposed to view in the roads and ploughed fields, imparting to the ground nearly as deep a color as the red ochre used as a pigment.

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*Three to five per cent.

This condition of the peroxide of iron appears to have a decided fertilizing effect; since deep sub-soil ploughing proves, I believe, always beneficial on these red lands. This amelioration may be, and doubtless is, in some measure, due to mechanical causes, contributing to drain the land of superfluous moisture; but its fertilizing properties are, in all probability, attributable, in part, to the power which the peroxide of iron has of imbibing ammonia from the atmosphere, and giving it out in time of rain to plants; for I find that these red sub-soils, though nearly destitute of organic matter, give out ammonia when treated with a solution of caustic potash, and, as far as I am able to judge from experiments at present instituted, in larger quantities than light colored soils, containing a few per cent. of organic matter. This is probably one of the principal reasons why the red lands of Cheshire, formed from the new red sandstone formation, as well as the red lands of Herefordshire, originating from the old red sandstone, are amongst the most fertile soils of England, especially well adapted for grazing farms. The peroxide of iron may possibly act, also, in other ways beneficially to vegetation, either as an oxydizer or neutralizer. We hope to throw further light on this subject if the chemical investigations of Kentucky soils be continued.

### SUB-CARBONIFEROUS SANDSTONE.

The base of the sub-carboniferous formation, in Jefferson and Bullitt counties, consists of fine-textured sandstones, partaking of the character of the argillaceous "*psammites*" of Brongniart. It differs from the ordinary sandstones of the Coal Measures and millstone grit not only in the fineness of the grain, but in the slightly adherent cement uniting the microscopic grains of quartz.

The alumina in these rocks often amounts to from ten to fourteen per cent.; the silica being in the proportion of about seventy per cent. Two principal varieties are observable: one a greenish grey argillaceous sandstone, the other a brown sandstone, containing nearly ten per cent. of oxyde of iron. The former, on account of its uniformity of surface, softness, and fine texture, works free before the chisel, and admits of being wrought into elaborate ornaments and even busts and other sculpture; but unfortunately it does not stand the weather well. The amount of argillaceous matter increases towards the base of the formation, so that it runs finally into argillaceous shales, embracing, locally, earthy limestones, rich in the remains of *Crinoidea.*

The upper part of this division of the sub-carboniferous formation is characterized by *Orthis crinistria* and *Spirifer cuspidatus;* the lower part by various species of encrinites belonging to the genera, *Antinocrinus, Agassizocrinus, Poteriocrinus, Synbathocrinus, Batocrinus, &c.*

Where this formation is well developed it weathers into ranges of conical hills, from two hundred to four hundred feet in height, such as prevail through the Salt River Knobs; hence the familiar appellation of "Knob Formation," appropriately applied to this division of the sub-carboniferous rocks in Jefferson, Bullitt, and Larue counties.

In the southern part of Kentucky, viz: in Monroe, Cumberland, Clinton, and Russell counties, this sandstone formation is hardly recognizable, its place being occupied with dark earthy limestones and limestone shales, extending to the base of the sub-carboniferous formation; these impart, however, a very similar contour to the country, as such rocks decompose with nearly the same facility as the argillaceous sandstones.

On the Ohio river, in Jefferson county, a belt of knobby country, about fourteen miles in width, extends from the foot of the Falls of the Ohio to the mouth of Salt river; thence it bears up the valley of that stream nearly south, with a slight easterly curve, to Muldraugh's Hill, dividing Taylor, Marion, and Larue counties, occupying part of Bullitt, the north-eastern edge of Hardin, the western corner of Nelson, and a large portion of Larue; thence it curves more to the south-east, through the corners of Taylor, Casey, and Adair counties; but having only partially explored the formation in that direction, I am not prepared, at present, to define its limits correctly, or to state where the fine-grained sandstone runs out and gives place to the limestone shales of Russell, Cumberland, and Clinton counties.

The knob sandstone produces a silico-argillaceous soil, very liable to wash, and therefore shallow and thin; the surface of the county, for the most part, broken. It seldom however forms of itself a purely characteristic soil, as it is commingled to a considerable extent with the "white soil" derived more immediately from the underlying ash-colored shales, which usually characterize the slopes, and narrow valleys hemmed in between the knobs, and occasionally intermixed with debris from a thin capping of sub-carboniferous limestone.

The agricultural areas impressed with the characteristics of this formation are, therefore, limited; indeed, the southern belt of this formation is so contracted that it may be said to occupy the slopes encountered in descending abruptly from the Lithostrotion beds of the former group, which prevail on the high grounds, to rocks of Devonian and Silurian date, occurring in the valleys.

The growth of the Salt River Knobs are:

Chesnut Oak, *Quercus prinus palustris;*

White Oak, *Quercus alba;*

Red Oak, *Quercus rubra;*

Black Oak, *Quercus tinctoria;*

A small Hickory, *Juglans tomentosa;*

Black Gum, *Nassa sylvatica;*

In favorable situations Poplar, and in flat and wet positions, Elm and Sweet Gum.

No chemical analyses have been completed of soils from this formation.

The argillaceous shales, at the base of the knob formation, contain some ironstones, but I have not yet had an opportunity of investigating this formation in Kentucky sufficiently to be able to give satisfactory information as to the extent, value, or productiveness of the ore, nor can I report, at present, on the strength and permanency of the brines which these strata may yield.

### BLACK LINGULA SHALE.

The greatest development of this formation, in the part of Kentucky hitherto explored, is in the immediate valley of the Ohio river. It crops out usually at the base of the knobs, in the form of a hard black shale, splitting in large sheets, sometimes with a rusty surface.

There are two narrow zones of out-crop of black shales of Devonian date in Kentucky, which converge towards the south, and diverge towards the north. Near the Tennessee line, where Monroe and Cumberland counties corner, these are separated only by a very narrow strip of underlying limestone, occupying the low grounds near the Turkey Neck Bend of the Cumberland river. In its north-easterly bearings through Cumberland, southern part of Russell and Casey counties, the area of this calcareous zone of Devonian and Silurian date continues quite contracted in its dimensions; as it reaches Lincoln county it begins to expand, so that the diverging belts of black lingula shale are some fifteen miles apart between the Gum Spring, in Rockcastle county, near the confines of Lincoln county, to Arsaff's Spring and the Flat Lick, in the neighborhood of Stanford. From here they continue to recede from each other; the westerly zone, skirting the base of Muldraugh's Hill, near the heads of the Rolling Fork of Salt river, and running thence down the valley of Salt river to the foot of the Falls of the Ohio; the easterly zone is deflected by the axis of inferior limestones to the north-east towards Madison and Estill counties; but I have not yet traced it in that direction beyond Boone's Fork of Dick's river.

At the foot of the Falls of the Ohio the black shale is a little over one hundred feet in thickness; at Muldraugh's Hill it is sixty to seventy feet thick, but graduates in its upper part into a grey argillaceous shale in the section exposed on the turnpike leading to the junction of the Rolling and Beech Forks of Salt river; on the waters of Goose creek, near the southern edge of Casey county, forty feet; on the declivity of Crider's Hill, in the southern part of Russell, twenty-nine feet; adjacent to the Tennessee line, on the confines of Monroe and Cumberland county, near McMillen's Ferry, Turkey Neck Bend of the Cumberland river, nineteen feet. Thus we perceive a gradually thining out of this formation towards the south. On the confines of Larue, Taylor, and Marion counties this formation has less bitumen in its composition; from a bituminous shale, at its base, it merges into ordinary grey argillaceous shales.

An axis of elevation in the valley of Barren river, on the east edge of Allen county, exposes fifty (50) feet of black shale, one mile above the turnpike bridge, resting on an impure greyish limestone near the water level. But three quarters of a mile below the bridge, borings reached the black shale only at forty (40) feet beneath the bank of Barren river. This is the only locality where I have as yet discovered the black shale so far west of its general bearings through the southern part of the State. It is probable that this is only a partial exposure from a local reversal or wave of the general dip.

The most important practical remarks to be made in this place, in regard to this formation, are the geological reasonings which have led me to dissuade citizens of the State from expenditures of time and money in search of coal in the horizon of the black lingula shale, and to advise the discontinuance of all undertakings having the same objects in view.

The close resemblance of this shale to the bituminous shales overlying or associated with beds of coal, has frequently led to the inference that there must be coal in the vicinity of its out-crop. Nay, it has too often been the case that even coal miners have adopted erroneous conclusions in regard to this vexed question, and, while passing through the country or settling in neighborhoods where this black shale is visible, have persuaded the inhabitants to undertake borings or shafts for the discovery of coal, laboring under the misapprehension that it is regular coal shale.

Having seen this black shale exposed in most satisfactory sections, from top to bottom, in nearly all the western States, and witnessed the results of borings carried for more than one hundred (100) feet entirely through it, we are now in possession of ample testimony to show the hopelessness of all attempts to discover workable coal in this geological position; a few streaks and isolated seams of an inch or two, is the only approach to coal that has ever been brought to light in this position; these, with perhaps also the bitumen, entering into the composition of the shale itself, indicate a feeble effort at vegetable growth on very limited points of dry land existing at the period of its formation. It was not, however, until long after this phase in geological cycles occurred that the circumstances favorable for the regular formation of coal began to dawn. Between the termination of the deposition of the black lingula shale and the commencement of the Coal Measures there elapsed a long period, during which more than one thousand (1000) feet of sedimentary matter subsided from suspension in water, or was precipitated from calcareous solution. The persistency and universality of the conditions which regulated the formation of extensive beds of coal in districts now occupied by the Western States of North America is sufficiently attested by the signal failures of all attempts in these States to obtain workable coal in rocks older than the millstone grit; and from the united experience of all geological researches in the same field tending to the same conclusion.

The soil derived exclusively from the black lingula shale is too retentive of moisture, forming what is familiarly known as "*spouty or crawfish land*," and is only capable of cultivation after a judicious system of drainage has beeen adopted in connection with deep ploughing. On account of the thinness of this formation in Kentucky, compared with what it is in Ohio and Indiana, the tracts of land formed solely from its decomposition, are quite limited, since it is, for the most part, either intermixed with silicious matter from the superimposed fine-grained sandstone, or calcareous matter from the overlying limestones and limestone shale. In either case the soil is greatly improved in texture and chemical relations.

This formation supports a growth of White Oak, *Quercus alba;* Overcup Oak, *Quercus macrocarpa;* Black Oak, *Quercus tinctoria;* which attain a good size in favorable situation; Beech, *Fagus sylvestris,* when the ground is rolling, but of stunted growth; Sweet Gum, *Liquidambar styraciflua,* and sometimes Black Gum; such are found especially towards the base of the formation. Midway, or thirty to fifty feet from its base, White Oak is the prevalent timber, with scrubby Black Oak, Hickory, and occasionally fine Elms, viz: both *Ulmus alata* and *Ulmus americana.*

On flat land, near the top of the formation, these above mentioned timbers are mixed with large Black Walnut, *Juglans nigra;* large Poplar, *Lyriodendrum tulipifera;* and Wild Cherry, *Cerasus virginiana;* on the slopes, small White Oak, a few Post Oaks, and sometimes Butter-nut at the foot.

Iron pyrites is one of the most abundant minerals disseminated in certain portions of these black shales. Such pyritiferous bands give rise, locally, to an unproductive soil, possessing sour, acrid, and astringent properties, produced partly by the passage of the pyrites into the acid sulphate of the protoxide of iron. This salt exercises a baneful influence on vegetation in two ways, when there is a difficiency of calcareous matter in the soil: the superfluous acid not meeting with lime sufficient to convert it into gypsum, corodes and chars the organic constituents, or alters them into inert forms, and the strong affinity existing between the protoxide of iron and oxygen promotes a deleterious deoxydizing influence.

Waters oozing from such pyritiferous clay-banks, or settling in pools on the adjacent soils, are impregnated with astringent salts, especially the double sulphate of alumina and iron. These are the situations where I have found some of the worst localities of milk-sickness that have come to my notice during the course of the past two seasons.*

The sour tendency of these soils is in part due to the standing water which collects on the impervious surface.

It is important, in this connection, to observe, that all these defects in such soils admit of correction, and some of them, by proper treatment, can indeed be turned to good account, in actually rendering them fertile, and especially well adapted for crops of clover and grasses, viz: by the application of lime or ground limestone the free sulphuric acid is at once neutralized and converted into gypsum, thereby not only improving the physical properties of the soil, but giving origin to a mineral manure remarkable for promoting the growth of clover and some other green crops.

By thus ameliorating the condition of these soils for agricultural purposes the farmer will, at the same time, greatly improve the health of the country and enhance the value of his lands.

During the deposition of the black lingula shales organic life seems to have been limited, both as to variety and size. Except a minute, simple-formed, tongue-shaped, bi-valve shell, belonging to the genus *Lingula*, locally distributed in the lamellae of this argillaceous deposit, we hardly meet with any organic remains.

### CORALLINE FALLS LIMESTONE.

Immediately underneath the previously described argillaceous beds a system of limestones occur, peculiar for the abundant remains of fossil corals which they contain, belonging mostly to those cylindrical, conical, and horn-shaped forms, known under the family appellation of *Cyathophyllidæ;* and to those hemispherical and cylindrical, honeycomb structured *Favosites*. So abundant are these at many localities that the formation may be denominated, in fact, a petrified coral reef. All those who have witnessed the multitude of these organic relics, imbedded in or standing out in bold relief from the surface of the exposed ledges of limestone on the Falls of the Ohio river, at extreme low water, will bear me out in the correctness of the similitude—I may even say, in the reality of the analogy—for here we find laid bare by the long continued action of the swift current of the Ohio, and the moldering hand of time, the exhumed remains of a by-gone world of polypiferous life, more ancient than the carboniferous rocks. Here we may contemplate even the delicate structure of extinct forms of radiata, once fixed to elevated inequalities, submerged beneath the waters of an ancient sea, cemented to the very rock that formed its base of support when alive, and its tomb after death; that rock now the bottom of a great river, serving as the channel of an extensive commerce, floated on its waters from the interior of a vast continent to the shores of a contracted sea, now receded more than five hundred (500) miles, by the most direct course, from the present site of these marine fossil relics.

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*Elsewhere I shall again advert to this subject more at large.

As with the preceding group, we find the greatest development of this coral limestone in Kentucky in the immediate valley of the Ohio. It consists of about fifty (50) feet of limestones which are, for the most part, hard and resisting, capped locally with an earthy limestone having hydraulic properties. These fifty (50) feet of limestones are the representatives of hundreds of feet of calcareous strata embraced in several important sub-divisions of both the Helderberg and Erie division of the New York system, and the cotemporaneous Devonian rocks of European Geologists.* Towards the south there is a gradual thinning out of this formation; indeed it is almost blended and merged in the succeeding limestones, so as to be hardly recognizable as a separate and distinct formation.

Commencing at the Tennessee line, in Monroe county, with an almost thread-like line we trace it slowly increasing in width towards Lincoln county, where it impresses decided features on the landscape and soil.

Divided into two distinct zones it runs parallel with the black lingula shales diverging with corresponding bearings, but little removed from the already described belt of that formation. The prevalent soil produced from these calcareous beds is highly productive—hardly inferior to the blue limestone soil.

Nothing can be more striking than the contrast in the features of the agricultural landscape observable in descending the Boone's Fork of Dick's river, as you pass abruptly from the stubborn cold soil of the black shale to the mellow calcareous lands of Lincoln county, in the vicinity of Crab Orchard. As soon the dividing strike-line is crossed everything bespeaks the wealth of the land owner.

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*For detailed description of the individual beds see second chapter.

The growth of timber, on this geological formation, is large Red Beech, *Fagus ferruginea;* large Poplar; Hackberry, *Celtis crassifolia.* Where windfalls have removed this earlier growth it is replaced by forests almost exclusively of large Black Walnut or Wild Cherry and Black Locust, *Robinia psuedo-acacia;* a few Buck-Eye, *Pavia lutea.* Very few Oaks are to be found in the woods on this formation, but occasionally on the points, large Butternut. Amongst the undergrowth Pawpaw, *Annona triloba,* and Grape Vines are conspicuous.

The widest belt of country where this formation gives character to the soil is in Jefferson county, where it is about eight miles across.

In the southern part of the State, on the Sulphur branch of the Cumberland river, in Monroe county, I have observed thin veins of galena and blende traversing limestones of this age crossing the bed of that stream with a bearing of north 20° east. These surface veins are however too thin to justify the expense of exploitation, especially as the sulphuret of zinc is more abundant than the sulphuret of lead in the surface veins. They might improve and be modified if followed to a considerable depth; still I have seen nothing in that section of country that can induce me to lend much encouragement to such an undertaking.

### CHAIN CORAL AND MAGNESIAN LIMESTONE.

In the southern counties of Kentucky the limestones referable to the date of the Niagara groupe of New York State, and the Upper Silurian rocks of Europe, are traceable only in a few feet of earthy limestone, or thin ledges of brown and buff magnesio-calcareous layers, almost destitute of organic remains, interposed between the beds of the preceding formation and the underlying blue limestone. The best development of these rocks that I have yet seen is in Jefferson county. The characteristic fossil—the chain coral—is well preserved in the vicinity of Beargrass, where it is silicified, and appears in strong relief on the surface of calcareous slabs like a cluster of delicately formed petrified chain-work, hence the scientific generic term *Catenipora.* The most abundant species is the *C. escharoides.*

The two sides of a triangle, of somewhat irregular form, having its apex at the Turkey Neck Bend of the Cumberland, and its terminating points on the Ohio river. The one in Jefferson county, the other in Lewis county, will give a general idea of the strike-lines of the two narrow belts of this formation, as they overlap, in opposite directions, the axis of the lower intervening blue limestone formation, sinking to the east and west under the previously described formation.

The width of the western zone of this formation, on the Ohio river, is twenty-two (22) miles, i. e. from a point a little above Louisville, in Jefferson county, to Garrett's Landing, in Trimble county; while its eastern zone is about eight miles, i. e. from near the confines of Mason and Lewis counties to Concord, in the latter county.

This formation has, as yet, been explored only to a limited extent in Jefferson and Lincoln counties.

In these strata we have the equivalent of the coralline and pentamerus beds of Wisconsin, immediately overlying the great lead-bearing magnesian limestones of the north-west.

In Kentucky the most characteristic growth of timber on the magnesian limestones of this formation is White Oak, of a hard and close grain, highly esteemed, on this account, by the steamboat builders, who will give nearly twenty per cent. more for it than any other oak found in the west. Gum and Water Maple may be also cited as congenial to the formation, with an undergrowth of green briars and blackberry briars.

The soil derived from these rocks is much inferior to that of the purer crystalline limestones of the overlying formation. When vestiges of these are found, capping the higher grounds, they form isolated fertile spots, forming quite a contrast to the surrounding magnesio-calcareous soil, which is more refractory, disposed to bake, becomes dry on the slopes, while they are too retentive of moisture on the flat land.

### BLUE SHELL LIMESTONE AND MARL.

The whole of the slightly curved undulating triangular area, having its base on the Ohio river between Garrett's Landing, in Trimble county, and the eastern limits of Mason county, with its apex curving a little west of south, to the Turkey Neck Bend of the Cumberland river, embraces the range of the axis of the great blue limestone in Kentucky. This consists of thin beds of bluish grey sub-crystalline limestones usually varying in thickness from a few inches to eight or ten inches or one foot, interstratified with fat marls and marly limestones, which predominate towards the base of the formation, over the more solid beds of limestone.

The chemical analysis of the ordinary blue limestone gave:

| | | |
|---|---|---|
| Specific gravity, | 2.680 | |
| Lime, | | 53.58 |
| Magnesia, | | 0.50 |
| Alumina and peroxide of iron, | | 1.80 |
| Carbonic acid, | | 42.30 |
| Phosphoric acid, | | 0.12 |
| Insoluble earthy matter, | | 1.30 |
| Moisture, | | 0.30 |
| Loss, | | 0.10 |
| | | 100.00 |

Towards the upper part of this formation, about seventy (70) feet below the four-foot banded earth magnesian limestone of the preceding group, there occurs, on Corn creek, in Trimble county, a peculiar variety of the shell limestone analyzed by Dr. Peter—see No. 164 of his Report.

This is the purest variety of limestone found in the formation, and is capable of receiving a good polish. On account of the large amount of calcareous spar which cements the shells and corals of which it is made up, and fills their interstices, it has nearly as white an appearance on the drove surface as white marble, and makes a very handsome wall; when worked up and polished it makes beautiful mantle-pieces and table-tops. Interposed between this formation and the four-foot banded rock occur dark grey earthy limestones, easily disintegrating by exposure. Some of these have hydraulic properties.

Extensive forests, composed almost entirely of Beech, may be considered indicative of this formation; interspersed with these are found Sugar-tree, Buck-eye, Linn, White Ash, Black Walnut, Poplar, and Coffee-nut, *Gymnocladus canadensis,* and not unfrequently fine Black Locusts.

The water in this formation is strongly impregnated with carbonate of lime, and is, sometimes, slightly turbid, from finely suspended particles of clayey matter, derived from the argillaceous marly beds over and through which it flows.

Dr. Peter's analysis, No. 27, shows the chemical composition of a virgin limestone soil from Fayette county; and No. 28 that of a soil from the same tract of land, that had long been in cultivation. His remarks following the analysis of No. 28 give his views of the cause of the fertility of this celebrated blue limestone soil. By comparing these two analyses it will be perceived, that by cultivation it has lost notable quantities of some essential ingredients of its fertility, which have been removed in different crops harvested and carried off the ground, viz: 2.02 organic matter, 0.11 of phosphate of lime, 0.066 potash; but we remark, at the same time, that there has been a gain from the argillo-calcareous sub-soil, by turning this up with a plough, of 0.036 of carbonate of lime, 0.127 of carbonate of magnesia, 1.224 of oxyde of iron and manganese, and 0.347 of alumina. This comparative chemical analysis gives, therefore, not only precise information necessary for the farmer to judge of the ingredients which his land has lost by cultivation, but also the exact *proportion* of these ingredients required to be added to restore it to its former fertility; it shows, also, how long this soil may be kept in cultivation without exhausting it of alkalies and salts which are essential to its fertility, and some of the great objects to be attained by deep sub-soiling. For other important practical remarks connected with this subject I beg to refer you to Dr. Peter's Report.

So characteristic are the agricultural peculiarities stamped upon the surface of every county within the range of this geological formation, that it has given rise to that generally recognized division of the State known as the "*Blue Grass*". country of Kentucky, justly celebrated for its fertility and consequent wealth. The unbroken tracts lying towards the heads of the streams rising in this formation, are indeed the "Garden Spot" of the State. We even hear the inhabitants of this part of Kentucky frequently styled "*Blue Grass Men*," in contradistinction to the "*Mountain Men*," residents of the adjacent hilly and mountainous country lying between its eastern confines and the Virginia line.

This part of Kentucky is not less remarkable in the annals of the Palaeontologist for the rich store which it supplies of extinct forms of shells, encrinites, trilobites, and corals, forming an endless study of research and unique cabinets of wonderful perfection. So prolific, indeed, is the blue limestone, in fossil remains, that continuous beds may be traced in which the imbedded shells and corals are so closely cemented that it would be difficult to place the finger on a spot without touching some of these organic relics. The contemplation of these must fill the mind of the observer with the profoundest reflections. Here is spread before his eyes more than five hundred (500) feet of solid rock, deposited at the bottom of a primeval ocean far more ancient than the coal formation that furnishes our fossil fuel; the age of which can, in fact, be traced back through nine vast geological formations, each many hundred feet in thickness, each the sepulchre of myriads of extinct races, that peopled this earth in succession, from the most highly organized human being down to the simplest marine life, forming the most elaborate history of the complicated phases of the earth's transmutations, and its physical progress; capable of being dissected and unfolded, so as to reveal to the science of geology the laws which operated to produce, in succession, the hidden stores of mineral wealth essential to civilized man, and lend the key by which he may unlock the treasure concealed beneath thousands of feet of rocky strata, and develope the means whereby these may be reached with the least labor and expense, to administer to the comfort and advancement of the human race.

In the fossiliferous strata of the blue limestone of Kentucky we behold, indeed, one of the oldest and deepest-seated of the stratified sedimentary formations, over which many miles of sedimentary particles subsided, during a long cycle of geological events; yet here, in the heart of Kentucky, do we find it reaching the surface, filled with exuvia of the earliest organized marine existences, whose elements now contribute, in connection with the mineral matter of which it is composed, to eliminate a soil, fertile and prolific, on which now waves the luxuriant harvests of an enterprising people, citizens of a great republic, happy in the advantages which surround them, happy in the repose which they enjoy, remote from the strife which now rocks Europe to its foundation, and immolates, by thousands, its human victims on the shrine of ambition, for the aggrandizement of its selfish rulers.

### REMARKS ON THE ORIGIN OF MILK-SICKNESS.

During the progress of the field-work a qualitative chemical examination was made, at the fountain head, of the principal chemical constituents of forty (40) different mineral waters, springs, and well water, to most of which medical or deleterious effects were attributed.

One of the principal objects which I had in view in carrying out this investigation was to ascertain whether that local and mysterious disease, known as the "*Milk-sickness*," originated from poisonous mineral substances, held in solution in the waters of the country; since some western physicians have attributed this disease to arsenic introduced through the medium of well or spring water, and derived from beds of arsenical pyrites, I had especial reference to this metal in these chemical investigations.

During the last summer I have had opportunities of testing some of the most suspicious waters in milk-sick regions, though not in their most concentrated forms, in consequence of the continued succession of rains.

So far as these investigations, and those of the summer of 1854, have yet been carried, in testing the unconcentrated waters, I find no confirmation of the disease originating from the presence of arsenic, or indeed of any of the other poisonous metals, such as lead, antimony, copper, or zinc; since sulphuretted hydrogen, passed to saturation through the unconcentrated waters, has failed to precipitate any of these metals, as sulphurets, which is considered one of the most delicate tests that can be resorted to.

I have, however, almost invariably found astringent salts, viz: the double sulphates of alumina and iron, and not unfrequently, chloride of magnesium—the former being derived from pyritiferous shales, the latter, in part, from silico-magnesian earths. Though it is doubtful whether these ingredients, held in solution in water, can be the origin or sole cause of the disease, yet it is highly probable that they tend to aggravate the complaint, and very likely bring it to a crisis, since the whole symptoms of the disorder bespeak a disease of astringency or torpidity of the secreting functions, and it is well known that the carcases of cattle known to have died of this complaint, are frequently found in the neighborhood of springs, and oozings from clay-licks, containing these astringent salts.

Sufficient evidence has been disclosed, in the last two seasons, to establish the fact that the disease is intimately connected with the geological formation.

All my observations tend to the conclusion, that wherever the disease is prevalent, pyritiferous shales or clays are in the immediate vicinity, producing by oxidation sulphate of alumina or the double sulphate of alumina and iron. These pyritiferous shales are not, however, confined to one geological formation; they are sometimes referable to the age of the quaternary formation, sometimes to the coal measures, sometimes to the black lingula shales of Devonian date, and even to the blue limestone formation. It is highly probable, too, that such pyritiferous shales may give rise to a species of vegetation producing astringent leaves or fruits, since it is an established fact in vegetable chemistry, that soluble saline substances will enter into the circulation of the plant, and may be found crystalized in the cells of its organization. Or these astringent salts may effloresce in certain conditions of the atmosphere, which may either creep up or otherwise settle extraneously on vegetation itself, or on the surface of the ground, after the manner of common salt in the neighborhood of brine springs and salt wells. I find, too, an opinion very prevalent in milk-sick regions, that, at certain times, white incrustations can be observed, both on the ground and on the leaves of the grass and other plants.

As this is a subject of vital importance to the inhabitants of the western country, it will be necessary for me to enlarge somewhat upon the views advanced in a previous communication in connection with this subject, particularly in multiplying my arguments to prove that the arsenic theory of the origin of the disease is untenable.

In poisoning with arsenic, in place of obstinate constipation, which is one of the prominent symptoms in milk-sickness, there is, usually, the very opposite effect produced on the bowels. Again, when arsenic is taken as a medicine for any length of time, it often produces dropsy in the limbs; and, though Christison doubts the power of the system to habituate itself to this poison, there are some reasons for believing that arsenic may be taken daily, in two grain doses, habitually, without producing any serious ailment until discontinued; and may, perhaps, even impart what some nations consider a fine complexion to the skin, and improve the wind for ascending mountains; which is the very opposite effect to that of milk-sickness; for both animals and men, who have contracted this disorder, are utterly incapable of exertion—the least exercise causing a trembling and complete prostration of the muscular system.

Reflecting on the general presence of iron pyrites through the milk-sick districts, and at the same time on the chemical affinities exercised by this mineral, it has occurred to me, as by no means improbable, that where a large amount of this sulphuret of iron is disseminated in a soil or adjacent clay bank, the powerful deoxidizing effect which it may exert while both its elements pass, on the one hand, into sulphuric acid, on the other, first into the state of protoxide and then into peroxide, that the lower strata of the atmosphere must certainly be robbed of a considerable portion of its oxygen. Now cattle, continually browsing with their nostrils close to the ground, may, in the neighborhood of pyritiferous earths, either as soils or clay banks, where they resort to lick, breathe an atmosphere deficient in the normal amount of oxygen. If so, the blood could not be properly arterialized. It would then lack the necessary quantity of red globules in the arteries; the carbonate of the protoxide in the venous blood, returning to the heart and lungs, would not be relieved of its carbonic acid, nor from the deleterious, deoxidizing influence of the retained protoxide of iron, all of which causes must necessarily contribute to stagnate the healthy circulation of the blood; feebleness and torpidity of the secretions would thereby necessarily ensue. If, in addition to this morbid reaction already established, astringent substances were introduced by the food into the stomach, or through the intervention of water or clay licks—a thing highly probable—in such situations; since a natural instinct draws animals inhabiting an extensive continent to resort to licks, especially when they feel indisposed. We have here, as heretofore remarked, a cause contributing greatly to aggravate the already deranged secreting organisms, and ample causes to explain the peculiar symptoms of the disease.

The known deleterious influence on vegetation of both sulphuret of iron and sulphate of the protoxide of iron therefrom originating, might, at first view, appear inconsistent with the fact that milk-sickness is often prevalent in tracts of rich land; but when we reflect that these pyritiferous beds are quite local in their position, and often accompanied with marly shales, destitute of iron pyrites producing a fertile soil, and that the injurious effect of the above minerals only lasts during the progress of the oxidation of their elements; while gypsum, a very fertilizing compound, is always the result of the introduction of sulphuric acid or soluble sulphates into a calcareous soil, whether it be by natural or artificial means; as this is ultimately the result of the peroxidation of sulphur, we see at once how we may have, in the immediate neighborhood, fertile lands. This fact may also explain the very local character of the disease, as well as its disappearance after cultivation and a thorough exposure of the soil to the free action of the atmosphere. So consistent does this chemical and physiological reasoning appear, with facts derived from the chemical investigations already instituted, that very little doubt remains in my mind of its being the true explanation of the cause of this mysterious disease, which has so long baffled the observations of both medical men and residents of milk-sick districts.

I believe, moreover, that soils impregnated with astringent salts are congenial to plants yielding astringent principles. At all events, oaks—especially the Spanish oak, which produces a very large acorn—prevails to a great extent in some milk-sick regions; and it is a very general belief, amongst farmers living in milk-sick regions, that the disease is more common where there is an abundant mast.

One of the most prominent and characteristic symptoms of the disease is the peculiar odor of the breath. This is, undoubtedly, the consequence of the total suppression of the secretion of the gastric juice, consequent on the constricted condition of the vessels which secrete this fluid, and the deranged circulation. All aliment which may happen to be in the stomach at the time undergoes, consequently, the ordinary fermentation which the same substances would undergo out of the stomach, subject to the same temperature.

If it be true, as asserted by some, that milk-sickness may originate without the intervention of milk, butter, or beef, then, I believe, that such cases must be caused either by the astringent effects of the waters of the locality, or by breathing a partially deoxidized atmosphere, or by the combined influence of both causes. As many of my readers may not have seen my remarks reported on the 29th May, 1855, I here subjoin, with one additional remark, what is there stated in regard to the treatment of this stubborn disease:

"Copious draughts of castor oil, or, in its absence, sweet oil, should be freely given, repeated even if rejected by the stomach, and, if possible, until it acts on the bowels, followed by the administration of sulphur and charcoal. If locality permit, sulphuretted saline waters will be found highly beneficial. Judging from the symptoms of the disease warm baths will be an important auxiliary. For animals, oils, sulphur, charcoal, and green salted corn, will be found most likely to relieve. Petroleum, seneca, or rock oil is said to be a very efficient remedy."

In this connection I would recommend, where practicable, the free application of caustic lime to all such land, i. e. land containing acid sulphates of alumina and protoxide of iron as a counter actor of the unhealthy influences in milk-sick districts; and as an important means of hastening the removal of the deleterious effects of these salts. It would not only facilitate the oxidation of the sulphur, by its catalytic affinity for sulphuric acid, but it would neutralize and remove this acid as fast as it was formed in the soil, and thus give rise to the formation of gypsum, which would not only greatly improve the fertility of the land, but it would, at the same time, purify the atmosphere of a redundant quantity of carbonic acid which would be apt to occur in a partially deoxidized atmosphere, and which is, moreover, apt to be generated wherever there is a rapid decomposition of vegetable matter, in hot and humid situations, and especially in confined valleys, where there are obstructions to the free circulation of air.

Such confined valleys are very likely to occur where shaly rocks are abundant, as these are easily gullied out by the action of air and water.

### DETAILED GEOLOGICO-TOPOGRAPHICAL SURVEY OF UNION AND PART OF CRITTENDEN COUNTIES.

The limited appropriation has only enabled me to commence the detailed work of the geological survey, and extend it over a comparatively circumscribed district.

At the very outset difficulties of a very serious nature presented themselves in carrying out this part of the work.

As the State of Kentucky was settled previous to the adoption, by the general government, of the rectilineal surveys now instituted, no systematic connected land surveys were ever extended over this State. Indeed, it is a fact well known to the citizens of Kentucky, that in most instances each settler made an independent survey of the tract of land he intended to occupy, according to his own notion or fancy—the lines being run by a surveyor engaged by himself, and who worked independently of his neighbor's survey. Hence we find, as might be anticipated, an almost total absence of correct geographical data in the maps of Kentucky. In many instances some of the principal streams of a county are eight or ten miles out of their true relative position, and of course the whole geography of the county is proportionably distorted. Besides, the existing maps are on much too small a scale to be serviceable for the purposes of the geologist.

Such being the actual condition of the maps of the various counties of this State, it became at once apparent that there was no possibility of laying down the detailed geology of the country with any degree of accuracy, without first mapping the country correctly.

How was this to be accomplished, and where was I to begin? These were grave and important questions.

My desire and first intention was to adopt, if possible, a system of triangulation and base lines, in connection with the desired lines of levels, that might serve as a ground work for defining the main ridges that embraced the great geological features of the country, that being the most accurate method of supplying the deficiencies of the present maps, and, at the same time, correcting the egregious errors in the position of streams, roads, plantations, &c., which, if permitted to serve as ground work for geological calculations, would inevitably lead to the most erroneous inferences.

When the district was selected for the commencement of the operations of the Topographical Assistant, and a preliminary examination had been made, it became then apparent that though there were, probably, a sufficient number of elevated commanding positions, from which to take bearings, that the density of the primitive forest, in obstructing the view from one station to the other, presented, at the present time, difficulties that must involve an expense quite incompatible with the means at my disposal, over at least a large portion of the tract to be mapped.

It became then a question, what description of survey could be best substituted and accomplish the desired object?

A regular system of rectilineal surveys, by townships, sections, and quarter sections, could not be adopted without the meridians and base lines to start from, which would require an outlay, at the first, of five dollars per mile, besides the subsequent division of the townships into miles square sections; that would require the measurement of sixty miles in every township, and additional travel of sixty more miles, making, in all, one hundred and twenty miles of travel, sixty of which have to be measured; this would amount, in the whole, to five times as many lines as would be required for laying down and correcting the topography of the country with sufficient accuracy for our purpose, and these regular section lines would not always be in the best position for defining geological boundaries.

It was finally, therefore, decided to adopt a system of traverse surveying by compass, chain, and level, with occasional measurement of base lines, chiefly conforming with the contour of the country, and the determination of conspicuous distant objects by angles of observation with transit theodolite, whenever the face of the country permitted, to connect such objects with the traverse lines; and by this means finally cover all that portion of the country, where the geological features required to be laid down, by a system of lines and triangles that could hereafter, where the forest was cleared away, be connected, if desired, with a system of regular trigonometrical surveys, and which, in the meantime, would afford the geological data required for the guidance of the geologist.

Some point on the Ohio river was evidently the proper position from which to start such a survey, it being the best—perhaps the only defined geographical boundary of the State—from the fact of its having been delineated from the surveys made in Illinois, Indiana, and Ohio by the United States.

The coal district of Union county lying on the Ohio river is the region where the detailed geodetic survey has been commenced; that being the district of country where the Lower Coal Measures reach the Ohio river, and abut against the sub-carboniferous limestones of Crittenden county; and where, in a given number of square miles, a greater variety of geological phenomena present themselves than in any portion of the State which I had, up to the time of the commencement of the detailed survey, visited in my general reconnoissance of the State.

The means at my disposal only permitted me to engage the services of a single corps in the prosecution of this work, and that corps could only be retained in the field during a limited portion of the season.

This, of course, did not admit of extensive operations. Nevertheless, the energy, industry, and dispatch which Mr. Sidney S. Lyon, the Topographical Assistant, brought to bear on this part of his duty, enables me to lay before you geologico-topographical maps of a much larger district of country than I at first anticipated.

No less than five hundred square miles have been covered by the geodetic survey in that space of time, embracing the whole of Union county and part of Crittenden.

This survey includes, not only the actual measurements by chain and compass, but the levels carried over the most prominent geological and geographical features; whereby, not only the streams have been correctly laid down, but nearly all the thoroughfares; and the main ridges, and even many of the subordinate ridges, have been meandered; all the roads drafted, and, in fact, every farm house placed in its proper position, except in a few instances, where they were situated far in level bottoms, beyond the view of the traverse lines circumscribing the upland and defining the boundaries of the bottom lands.

The whole of this has been plotted on a large map, on a scale of 3.8016 inches to the mile, and is now being reduced to a convenient size, viz: $\frac{1}{50,000}$ of a mile, equal to 1.2672 of an inch to the mile.

These maps not only supply the geodetic features whereby to establish the true comparative position of any geological formation, and delineate its dip and strike and physical outline, but they furnish, at the same time, geographical information to every settler, the value of which can hardly be realized until the maps are closely inspected by those well acquainted with the country, and compared with the previously existing maps. An illustration will bring this more clearly home to my readers: If the position of Cypress creek, in Union county, be examined on the best maps hitherto extant of that country, it will be found to be at least nine miles out of its true position, flowing, as it is represented on the newest existing maps, three or four miles *east* of the Caseyville and Morganfield road, with a general bearing north and south, and about fourteen miles from the nearest point on the Ohio river, below Shawneetown; whereas, it drains the country entirely *west* of the Morganfield road, for the greater part of its length, forming a long sweep to the west, and extending to within three miles of the Ohio river at the westerly part of the curve. Yet this is the main stream, and the principal geographical feature to which all the topography of the country necessarily conforms; consequently the whole geography of the country is completely reversed. Lost creek is equally false.

These are no solitary instances of such flagrant errors in the geography of the country; very many of the counties are as incorrectly represented in their topography, as the instance here cited.

The necessity of a combined system of geologico-topographical surveying is thus clearly manifest.

Unless the dip and strike lines of the geological formations can be accurately platted, and the horizontal distance from these lines can be measured with great precision, it is impossible to make any reliable calculations as to the identity of beds, or estimate the relative thickness of the intervening measures.

It is data of this kind which gives the chief practical value to geological details.

The calculations forming the bases for the construction of the geological sections of this report, showing the superposition of the beds of coal of Union county, and the exact thickness of the intervening measures, have been derived mainly from measurements on the geologico-topographical map thus constructed.

Every citizen of Kentucky will be able to appreciate the valuable information they convey. I only regret that the means placed at my disposal did not enable me to extend these detailed surveys over a greater number of counties.

The cost of such a survey will be from four to six dollars a square mile, depending on the nature of the country, its accessibility, and the complexity of its geology. A county of five hundred square miles can be surveyed on this plan for about two thousand to two thousand five hundred dollars.

In my opinion the geographical information obtained would alone justify this outlay, independent of the geological survey therein embraced; and it is to be observed that the above amount includes not only the topography but numerous lines of levels, geodetic and geological observations; but it does not include the drafting of the maps, which will cost from one hundred and eighty to two hundred dollars more.

To define merely the boundaries of geological formations it would not be necessary to extend these detailed topographical surveys over the entire State. An area of about ten thousand square miles would probably comprise the district required for accomplishing that object.

The government surveys in Louisiana, where there is a good deal of tangled, swampy ground, is nine dollars per square mile, as well as in the wet parts of Arkansas; but this is considered hardly sufficient to remunerate the surveyor, and it is proposed by the Commissioner of the United States Land Office to increase it to eighteen dollars per square mile. Where there is prairie and wood-land together the average cost of land surveys, in all the States together, is twelve dollars and fifty cents per square mile—rising as high as twenty dollars per square mile in difficult situations.

The trigonometrical surveys carried on by the office of the Coast Survey, where the country is unobstructed by forests, and where large bodies of water admit of extended observation, cost twenty-two dollars and fifty cents per square mile, with the topographical drawings, and twenty dollars and twelve cents without the drawings. The topography alone, without primary triangulation, detailed triangulation, and astronomical observations, costs six dollars and eighty cents per square mile.

In order to be able to lay off the map into squares, for the purpose of reduction and transfer, the Topographical Assistant has carried the township and section lines of the adjacent counties of Hardin and Gallatin, in Illinois, and Posey county, in Indiana, over into Union county, which form the basis of a system of rectilineal net-work, covering the country, and dividing it, at the same time, into provisional square miles. These, when systematically numbered, form a very convenient method of reference and geological designation. As it happens one of the north and south township lines passes through Uniontown; this has been adopted as a meridian, from which to designate the adjoining townships east and west from that meridian; while an east and west township line, passing by the mouth of Highland creek, has been selected as a base line, which throws the body of the townships south of this base line. This base line, when produced, would divide the State centrally.

The part of Kentucky selected for the commencement of the detailed geologico-topographical survey presents probably not only the greatest number of seams of coal in a short distance, but some of the most remarkable disturbances of the original arrangement of the beds to be found in the whole western country.

The principal axis of this disturbance is to be found in the bed of the Ohio river, nearly opposite Shawneetown. Here the lower coals and conglomerate are tilted, at very high angles—in some places nearly into a vertical position. The strike line of this great up-cast appears to be at first nearly coincident with the Ohio river, whence it bears off east north-east, by the "*Foot Print*" locality and the Bald Knob, toward the chalybeate and sulphur springs, five miles south-east of Morganfield. On either side of this up-lift, in the immediate valley of the Ohio, there are immense depressions and elevations of the strata, which carry the Lower Coal Measures of Union county, Kentucky, and Gallatin county in Illinois, aruptly up to the extent of at least one thousand feet. It is part of the same disturbance which causes the Coal Measures immediately under the Anvil Rock to disappear suddenly beneath the valley of Hines creek, and imparts to the Coal Measures cropping out, on the east side of the Saline, a few miles above its mouth, that long north-easterly slope, which extends to the Ohio bottom and the base of Gold Hill, where we find the main axis of Gold Hill continued into Gallatin county, Illinois.

It is this same disturbance which has wrinkled and folded the Coal Measures, and raised them into swells, conforming, in a great measure, to the main ridges of Union county, and given to the rocks flanking the Bald Hill range that southwardly dip, forming an obtuse angle with the north-easterly dip of the Coal Measures lying south of Hines creek, in consequence of the curved form of the strike line between the two localities.

# CHAPTER II.

In this division of the Report is embraced a record of local obserservations in individual counties, intended for neighborhood reference, and for further illustration of the subjects treated of in *general terms* in the preceding pages.

The counties will be classified according to the geological formation to which they belong, both for the sake of brevity and system.

## LOCAL OBSERVATIONS

### *In the Quaternary Formation of McCracken, Ballard, Hickman, Graves, Fulton, and a great part of Calloway and Marshall counties.*

In the absence of solid beds of freestone and limestone for constructions in the Quaternary Formation a substitute is found in the so-called "*Cement Rock*," which has been formed, or is forming, by the infiltration of chalybeate waters through the gravel, which underlies the fine loams and marls of this region, cementing it into a ferruginous conglomerate, which can be used for under-pinning, walling up wells, and similar purposes. Near the mouth of Clark's river, in McCracken county, it occurs in considerable quantity, and can be observed in process of formation. Near Ballard's Ford there are also immense masses of the same kind of rock. Other localities, where this ferruginous conglomerate has been observed, are Robb's Mill, Kenton's Farm, on Perkins' creek, five and a half miles from Paducah, in the county of McCracken. At the first of these localities there are, however, solid ledges of hard ferruginous and quartzose sandstone in the high ground south-east of Mr. Robb's house, which probably belong to the age of the millstone grit series.

At the Iron Banks, above Columbus; near Mills' Point; in the bluffs near David Unsel's; in the neighborhood of Fort Jefferson, in Ballard county, heavy masses of the same material exist; also along the waters of Clark's river, both in McCracken and Marshall counties; on the waters of Mehan's creek, north-west of Graves county; on the waters of Mayfield creek, in the northern part of the same county, and the southern part of McCracken.

Calcareous waters, filtering through the quaternary sands, loams, and marls, have sometimes cemented these for limited spaces into a tolerably hard material; for instance, at the Iron Banks, above Columbus, and in the bluffs about Hickman, in Fulton county; on the waters of Little Mayfield, in Graves county; but these rock are not generally to be relied upon as substantial building stones.

At Boyd's, one and a half miles west of Paducah, limestone is said to occur, and sandstone is found at Baer's place. On Big Cypress there are solid ledges of hard limestone belonging to the Sub-carboniferous Formation. In the bed of the Mississippi, nearly opposite Fort Jefferson, there is said to be solid rock, not, however, exposed above low water. The most rocky part of Jackson Purchase borders on the Tennessee line, in Calloway county, where both the limestone and chert of the iron district of the sub-carboniferous group are exposed in conspicuous benches.

These localities are, however, exceptions to the general diffusion of incoherent earthy deposits through these south-western counties of Kentucky.

In digging wells in Graves, Marshall, and Hickman counties water is sometimes obtained above or on a level with the gravel bed, and sometimes only after passing through or into a white sand, reached at the depth of eighty to ninety feet beneath the general surface of the uplands.

Waters impregnated with oxyde of iron, of the same nature as those which cement the gravel beds into ferruginous conglomerate, appear occasionally in the form of chalybeate springs, issuing beneath the level of the gravel bed. One of the most interesting and strongest of these, which I have had occasion to test, occurs in the banks of Massac creek, on the property of Mr. Robb, in McCracken county.

The protoxide of iron, when existing in natural waters, in combination with carbonic acid, is very rapidly peroxidated and deposited from its state of solution, and, in general, chemical re-agents only detect its presence by a feeble reaction, even when the water is tested at the fountain head, so that, when free from the *sulphate* of the protoxide of iron, the blackening (reducing) effect, on the addition of nitrate of silver, and a drop or two of ammonia, is seldom distinctly visible. Not so, however, with this chalybeate water of Massac creek; though it produces no distinct precipitate with nitrate of baryta, proving the absence of any notable quantity of *sulphate* of the protoxide of iron, it is instantly blackened by the application of a drop or two of nitrate of silver and ammonia, demonstrating its powerful deoxidizing properties from the presence of a much larger quantity than usual of *bi-carbonate* of the protoxide of iron. Such chalybeate waters have, according to my experience, much more decided medicinal effects than those which indicate little or no deoxidizing power with the same re-agents, in the absence of sulphate of the protoxide of iron.

I not only find a difference between the extremes of these natural chalybeate waters, but a decided *gradation* in their deoxidizing powers. The Robb spring contains, besides chloride of alkali, (probably chloride of sodium,) some chloride of magnesium, and less bi-carbonate of lime and magnesia than is usually found in ordinary spring water. It has an acid reaction on litmus paper at the fountain head; but I believe, if boiled down until all the carbonic acid was expelled, it would probably have an alkaline effect from the presence of carbonate of alkali; this, however, I have as yet had no opportunity of verifying by experiment.

Immediately around this spring there is a luxuriant growth of Birch trees, larger and more numerous than I recollect to have noticed elsewhere in the district.

This spring is worthy of a minute chemical quantitative analysis, for I believe it will be found to have very beneficial effects both as an anti-periodic, tonic, antiseptic, and, at the same time, slightly aperient, excellent in intermittents, debility, and feeble digestion. To make a satisfactory quantitative analysis of this water it would require a special visit of the chemist to the spring, where both the carbonic acid and protoxide of iron should be fixed at the fountain head before transportation to the laboratory. In boring for water at Mr. Robb's, a white silicious clay was passed through at forty feet, overlaid by yellow sand, just before reaching the water.

An insight is obtained into the succession and thickness of the quaternary deposits of Ballard county from the materials passed through in digging wells, which are usually as follows:

| | | Feet. | Inches. |
|---|---|---|---|
| No. 1. | Soil, | 4 to | 6 |
| No. 2. | Subsoil, yellowish clay, | 2 | |
| No. 3. | Dark stiff clay, with black seams, | 12 | |
| No. 4. | Gravel, | 20 to 12 | |
| No. 5. | Land generally yellow; getting whiter in the descent; and occasionally cemented into solid masses; some times | 120 | |
| No. 6. | Sometimes (in one fourth of the wells) a white clay like that described as occurring at the so called "*chalk banks,*" on the Mississippi, | 4 | |
| | | 150 | 6 |

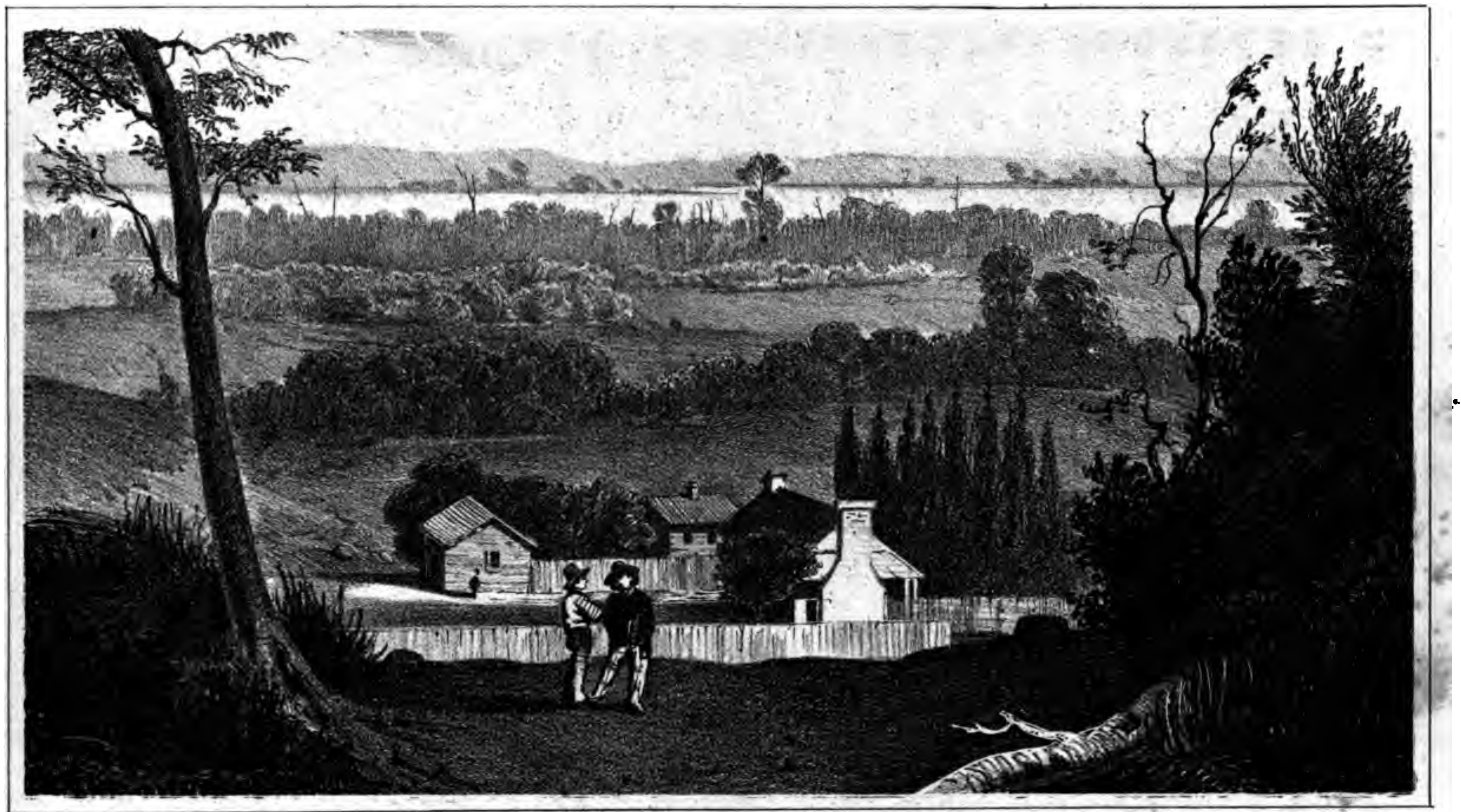
When water is not obtained after penetrating bed No. 3, it is generally necessary to sink to the white sand and clay. The white clay occurs where the land is broken; seldom, if ever, when the country is level. Logs, leaves, and other remains of timber occur 100 feet below the surface of the highest ground in bed No. 6 of the preceding section. The lignite and brown coal found in the bluffs of Fort Jefferson, and probably also elsewhere in the Jackson Purchase, occur in the same bed, No. 6, at an elevation of from 30 to 50 feet above high water of the Mississippi river. At some localities I have found whole logs, retaining the form and structure of the original wood, completely converted into black lignite and jet, hard enough to ring under the hammer. See Dr. Peter's Report, No. 3, for an analysis of one variety of this lignite.

Another variety analysed in my laboratory yielded,

| | | |
|---|---|---|
| Specific gravity, | 1.201 | |
| Total volatile matter, | | 53.0 |
| Coke, | | 47.0 |
| | | 100.0 |
| Moisture, | 30.0 | |
| Volatile combustible matter, | 23.0 | |
| Fixed carbon, | 40.0 | |
| Ashes, (flesh color,) | 7.0 | |
| | 100.0 | |

Immediately opposite the "Iron Banks" the Mississippi is 96 feet deep; the waters sweeping along the base of the quaternary deposits with immense velocity; the consequence is, that the incoherent beds at the base are rapidly undermined, and every now and then extensive

PL. Nº 6



D. D. Owen del.

Robyn & Co. Lith. Louisville Ky.

DISTANT VIEW OF REEL-FOOT LAKE, FORMED BY THE EARTHQUAKE OF 1811.

slides of the entire bank occur, precipitating immense masses into the abyss beneath. (See plate No. 2.) In the Spring of 1847 seven acres were thus carried away. This afforded a favorable opportunity of inspecting the section of these quaternary earths given in the preceding chapter, except at the base, which is covered by the talus; these are, however, exposed to view at the "Chalk Banks" at the next bend below. The plane of deposition of the deposits is rather irregular, and sometimes abrupt, giving the appearance of a strong dip of 8° to 10°. The deep cut of the Mobile, Mississippi, and Ohio Railroad has exposed from 15 to 20 feet of the fine silicious marl of which an analysis is given in the first chapter; but the hill through which the road passes appears to be composed of the upper beds which have slid from an original higher level, as it contains the same species of land and fresh water shells enumerated as occurring in bed No. 3 of the section at the Iron Banks, overlying the hornstone gravel at an elevation of from 120 to 160 feet above low water of the Mississippi.

In Ballard county a mixture of the poorer soils and sub-soil, Nos. 1 and 2 of the section, supporting a growth of briars, appears to be better adapted for the use of the brick maker than the tenaceous clays at the base of the section, which contain too large a porportion of alumina to be worked without admixture of other earths.

When in Fulton county I visited the extreme south-western portion of the county, lying adjacent to the Mississippi, on the borders of Reel-Foot lake, immediately opposite to New Madrid, in Missouri, the well known centre of action of the earthquake of 1811, being desirous of ascertaining the extent and nature of the disturbances and changes of level which could be traced on the surface of the country in Kentucky.

It appears that previous to the earthquake in question Reel-Foot lake had no existence. It was formed immediately succeeding the catastrophe, by the formation of a "*sand-blow*" near the mouth of the then existing Reel-Foot creek, which, being thereby dammed off, spread its waters over the adjacent low grounds, forming an extensive lake, and deadening all the timber then growing in the bottom of Reel-Foot creek. The deflected waters henceforth turned their course to the south, and emptied into Obion river. Plate No. 5 represents a view of a portion of this lake; its surface covered to a great extent with Water Lillies. In the shallow places dead Cypress timbers stand in clusters that obstruct the view; their trunks blackened and partly consumed by the hunter's fire, which, in a dry time and during high winds, is wafted from the adjacent high grass, on the shore, in spite of the water barrier, to the highly combustible resinous timber.

At the Narrows this lake is three quarters of a mile wide. Its precise length I have not been able to ascertain, but it is probably about seventeen miles. Some individuals estimate its length at fifty miles; but they probably include in this also Obion lake. Its greatest depth is given at twenty feet, and its greatest width about two miles and a half.

Sketch No. 6 represents a distant view of part of this lake near the boundary between Kentucky and Tennessee. Its course can be traced, where its waters cannot be seen, by the tops of the dead timber. The country was, doubtless, wet and marshy before the great earthquake; but the great body of this lake was formed by that catastrophe.

It is a great resort for all kinds of water fowl, lizards, snakes,* and musquitoes, and it affords a variety of excellent fish, a few Unios and Paludinas. On the borders of the lake is a very luxuriant growth of wild grass, known to the inhabitants under the name of "Game Grass," which dries into a nutritive hay, very attractive to herbivorous animals.

This part of Kentucky, and the adjoining county in Tennessee, is said to have been the favorite hunting ground of Davy Crockett.

In the bluffs adjacent to Mr. Carpenter's various ancient stone implements, earthern ware utensils, and carved images are found, associated with human bones, affording evidence that this country has once been the site of some considerable aboriginal village.

The region of Reel-Foot lake is subject to frequent severe hurricanes, that prostrate the largest trees along the line of their course, and it is the opinion of Mr. Carpenter, who resides immediately on its borders, that many of them *originate* here, usually taking a north-east course. One of these, which cannot be traced further south, took place between 9 and 10 o'clock on the 20th of March, 1834, passing by Feliciana, on the edge of Graves county, destroying, in four miles, six or seven houses, and carrying clothing many miles, (some say twenty miles.)

---

*The Cotton-mouth snake is very common in this lake.

Though the *"earth-cracks"* can be distinctly seen in the bluffs on the Kentucky side of the Mississippi, yet they are by no means so conspicuous as on the Missouri side, near New Madrid, or in Obion county, Tennessee.

In the bluffs of the Mississippi, half a mile from Mr. Carpenter's house, earth-cracks can be traced for a quarter to a half a mile, twenty to seventy feet wide, bounded on either side by parallel banks one to five feet above the sunk ground, the trees still growing firmly rooted in the soil.

In Obion county, Tennessee, depressions are even now visible one hundred feet deep, and varying from a few feet to upwards of one hundred feet wide, which are said to have been more than double this depth when originally formed.

Twelve miles from Hickman, on the road to Feliciana, on Little Bayou du Chien, in Fulton county, the country is watered by several fine springs. I tested five of these at the fountain head, and found them to contain no more than the ordinary quantity of alkaline earths that occurs in the spring water issuing in the Jackson Purchase above the gravel beds. The country between Hickman and Little Bayou du Chien is based on the same kind of fine silicious soil as No. 1, analyzed by Dr. Peter. It supports a growth of heavy timber, viz: Poplar, Oak, Sugar-tree, Elm, Walnut, Gum, and a few Cucumber trees.

In sinking a well at Squire McFaden's, four miles from Little Bayou du Chien, there was passed through, under the soil and sub-soil, which were very much alike in appearance, twenty-five feet of coarse red sand; then sixty feet of white sand, with alternations of clay from one to two feet. At one hundred and eleven feet he obtained water, which gave, with re-agents, the same indications of purity as the spring water previously examined on Little Bayou du Chien, and is probably on the same level from our observations of the height of his house above the valley of Bayou du Chien.

In the southern neck of Hickman county the soil is coarser, and the Oak timber more prevalent, which becomes smaller in size on the western edge of Graves, near Feliciana. To the north of that place small Birch trees appear along the creeks.

In the neighborhood of Feliciana water is reached at from ten to eighty-five feet, on penetrating a yellow quick-sand of the Quaternary

Formation, with alternations of clay, much of the same character as the deposit passed through at McFaden's.

At the Moberly Camp Ground, near the steam-mill, I found small quantities of hydrated brown oxyde of iron, in the vicinity of a concretionary ferruginous sandstone, which probably occupies the geological horizon of the previously mentioned ferruginous conglomerate; but it does not appear to be in sufficient quantity to be of much practical value.

Six miles of the south-western portion of Graves is the heaviest timbered part of the county; it is especially good between the Moberly Camp Ground and the State line.

Soon after leaving that point, in the direction of Mayfield, a growth of Black-jack, and a soil like the northern and eastern part of Ballard sets in.

Between the head waters of the Little Obion and Mayfield, the country was originally a prairie. A great portion of it is now grown up in Black Oak, with some Black Walnut near the water courses. The timber and general appearance of the soil indicates an approach to the confines of the barren limestone formation, which, though concealed by the superficial quaternary deposits, is probably the rock on which these repose. At the crossing of the Brush creek branch of the Little Obion a gravel bed makes its appearance, and two springs issue a few hundred yards to the west of the road.

In the eastern part of Graves county, on Panther creek, on the land of Mr. Prior, there is an interesting section of quaternary deposits overlying a bed of earthy brown coal.

| | | Feet. |
|---|---|---|
| 1. | Yellow sand, irregularly mixed with clay and pebbles; locally indurated into a soft rock, - - - - - - - - - | 30 |
| 2. | Carboniferous chert and hornstone gravel; six feet indurated, - - | 10 |
| 3. | Dark and dove-colored indurated clay, with leaves of Willow and other remains of exogenous trees, and containing bituminous, ligneous matter, - - - - - - - - - - - - | 2 to 3 |
| 4. | Earthy brown coal or lignite, - - - - - - - - | 9 |

The bed of brown coal can be traced from fifty to one hundred yards along the banks of Panther creek; and Mr. Prior says he has observed it on a branch half a mile to the east of this locality. It seems to rise slightly with the swell of the hill.

The quaternary deposits are here more indurated than usual. The imbedded leaves in bed No. 3 of the section clearly demonstrate the age of the deposits, and prove, if other data were insufficient, that this coal cannot belong to the regular coal formation.

Time has not yet permitted an analysis of this brown coal. Mr. Prior bored twelve feet below the brown coal, and struck water, which rose to the surface, and caused him to suspend further examination.

The same deposits of sand and clay, with carboniferous gravel disseminated, that overlie the brown coal, were passed through in sinking a well in Mr. Prior's yard. At eighteen feet he obtained abundance of water.

At Mayfield, in the centre of Graves county, they had to go eighty-nine feet to water. One well of this depth supplies the whole town. When fresh drawn it had a temperature of 59°, the temperature of the air at the same time being 95°. No brown coal or lignite was known to have been penetrated in the material passed through in digging this well.

The Red Oak, *Quercus rubra*, and Mockernut Hickory, *Juglans tomentosa*, indicate the best land of this part of Graves county, which is excellent for tobacco and hemp, and good for oats and corn. The inferior land has a growth of Post Oak, *Quercus obtusiloba*.

The soil will be greatly improved by deep sub-soil ploughing, which will not only bring new chemical elements into requisition for the use of the plant, but enable the crops to stand the droughts of the latter Summer months with more impunity, since it will modify its texture and increase its retentive properties, and thus the roots will be more liberally supplied, not only with moisture, but with ammonia absorbed from the atmosphere.

The best soils of Graves county are capable of producing twenty to thirty-two bushels of wheat, weighing sixty pounds to the bushel, on an average, and sixty-eight pounds in the most favorable seasons. They will average one thousand pounds of tobacco to the acre. On some farms as much as one thousand four hundred pounds have been raised on an acre of new ground. This tobacco, and indeed that grown in the Purchase generally, is said to command the highest price given for Kentucky tobacco in the southern market.

On the Wilson branch the following materials are passed through in digging wells:

| | | *Feet.* | *Inches.* |
|---|---|---|---|
| 1. | Soil, - - - - - - - - - - - - - | 4 to | 6 |
| 2. | Sub-soil, - - - - - - - - - - - - | 2½ to 3 | |
| 3. | Ash-colored earth, tough and sticky, - - - - | 3 to 7 | |
| 4. | Irregular mixture of sand and clay, with leaves, wood, and pebbles interspersed, - - - - - - | 12 | |
| 5. | Gravel, - - - - - - - - - - - - | 4 | |
| 6. | White, yellow, and pure sand like sugar, - - - | 20 to 50 | |

Here water is struck at the depth of about forty feet, on an average, but varying from twenty to ninety feet, depending on the elevation of ground where the well is commenced.

Where a section of the strata is exposed, in the Natchez bluff of Wilson's creek, there is first fine sand and clay, without gravel, on the top, corresponding to No. 3 of the previous section; then a reddish-yellow sand, irregularly mixed with gravel, and reposing on the main gravel bed beneath, at the bottom of the section. In some places, below the gravel, the sand is concreted into a soft sand rock of a yellow color, with cavities containing white sand.

The slopes of the hills in the northern part of Graves county, on the waters of Mayfield creek, are strewn with carboniferous chert and hornstone gravel, amongst which were found worn specimens of *Lithostrotion;* and in the cut of the road ascending to Mr. W. Futrell's, a mixture of white and yellow sand is cemented into soft rock, through the intervention of chalybeate waters, overlaid by ferruginous conglomerate and concretionary sandstone. The soil here is of an ash color; the sub-soil yellow, and mixed with gravel, and the surface broken into isolated knolls and intervening hollows.

In the neighborhood of Camp Creek the soil is fine loam, overlying the gravel bed, supporting a growth of white and black oak. In the flats of Camp creek clay, with calcareous and ironstone concretions and black carbonaceous matter interspersed, is visible.

The reported coal of the Blizzard Pound country seems to have no better foundation than the carbonaceous matter here and there disseminated in a stiff clay, near the level of Clark's river, in the vicinity of Boland's ford, which gives it a very black appearance. Pyrites is also diffused through this clay below the ford; this, together with a silvery mica diffused in the sand, and the occurrence of some ferruginous conglomerate found at the "Fish Rock" and elsewhere, has given origin to various reports in regard to the existence of valuable ores in this part of McCracken. At Bronnell's mill, on the west fork of Clark's river, twelve feet is exposed of a dark indurated clay, intersected with nearly vertical sun-cracks, into which micaceous sand, such as occurs above it, has infiltrated and become hardened into a species of rock.

Walford's mill, three miles east from Bronnell's, is built in a bank of the same material, showing a wide distribution of this deposit above the level of the waters of Clark's river. It is sometimes sufficiently hard to be used for walling up wells. This, at Bronnell's mill, is overlaid by a gravel bed, some twenty to twenty-five feet in thickness, of hornstone and chert; some of which is cemented by iron into the ferruginous conglomerate so generally distributed through the Jackson Purchase.

Near Mr. Griffith's the same indurated clay shows itself, ten feet thick, overlaid by gravel, which latter is reached, generally, about eight feet below the surface.

On an adjacent farm the indurated clay has been penetrated thirty feet, becoming quite black towards the base, from the presence of bituminous or other vegetable matter, and passing ultimately into a kind of black, sheety shale.

A mineral substance has been found on this part of Clark's river, which, I suppose from description, are small crystals of selenite or transparent sulphate of lime, derived, probably, from the mutual decomposition of pyrites and calcareous concretions in the indurated clays, shale, and sands of this vicinity.

The quaternary deposits on this part of Clark's river, in Marshall county, appear to be very analogous to the materials passed through in digging wells on the waters of Island creek, in McCracken county. There selenite has also been found, apparently in veins traversing a black argillaceous shaly rock underlying ferruginous conglomerate and variegated clays, about nineteen feet beneath the general surface of the country, just before coming to water; which is about the average depth at which water is reached in the portions of Marshall county based on similar deposits.

From the occasional occurrence of pieces of iron ore of the limonite variety, and close inspection of the composition of the deposits mentioned above, there is a probability that the valley of Clark's river lies along the confines of the junction of the sub-carboniferous rocks and the Devonian black shale. The indurated clays and subordinate black shale prevalent at the base of the sections, obtained in the lowest cuts of the streams and excavations for wells, appear to be either the debris derived immediately from the lowest sub-carboniferous argillaceous strata and black shale of the Devonian Period, or perhaps actually the denuded surfaces of these beds in place.

Soil has been collected for chemical investigation from the Black Oak Lands of Marshall county, in which wild rye grows spontaneously; but this soil, together with many others of equal interest, have not yet been analysed, for want of time.

On the waters of the East Fork of Clark's river, in Marshall county, the gravel bed is from ten to twenty feet thick, extending nearly to the level of the river. It is under this formation that the water is usually obtained in the wells of this part of Marshall.

In the waters oozing from the pyritiferous shales of Waide's creek I find abundance of astringent salts, having a base of alumina, protoxide of iron, and magnesia.

The formation of the lands of Calloway county, adjacent to Clark's river, are much the same as those just described in Marshall. In the base of the ridges of Wild Cat creek a light yellowish ash-colored quaternary clay is manufactured into stone ware, at Capt. Bonner's pottery. To prevent this clay from cracking it is mixed in equal proportions with a more meagre silicious bed, occurring in the same district, at a lower level. This ware sells at six cents wholesale, per gallon, at the pottery, and ten cents by retail.

After being broken up, the clay is sifted to free it from vegetable fibre and any disseminated pebbles, and then ground with water in a rude horse-mill until properly tempered, turned on the potter's wheel into crocks, jugs, churns, and various other forms, burnt for a day and night until it turns of a warm cream-color, and then glazed with vapor of salt thrown into the glowing kiln.

Many of the quaternary clays and silicious earths, when free from calcareous matter, are well adapted for this kind of potters' ware, from the very fine state of division in which the material is naturally found. If there is a notable quantity of carbonate of lime then the earth is either too fusible or the caustic lime disseminated in the burnt ware slacks and causes the ware to disintegrate.

On the waters of Blood river, in Calloway county, a bed of quaternary lignite has been traced for about two hundred yards, of four feet in thickness, covered by a thin layer of blackish sand; then yellow clay and gravel.

On the waters of Sugar-tree creek, and the head waters of Jonathan's creek, in Calloway county, the gravel beds are of great thickness. Seven or eight miles from the Tennessee river forty-five feet of gravel has been passed through in digging wells. This is on the confines of the iron region of Blood river, a district to be spoken of elsewhere.

### LOCAL OBSERVATIONS

### *In the Coal Measures of Hopkins, Muhlenburg, McLean, western part of Butler, and northern part of Christian counties.*

The thickest and best coals yet examined in Hopkins occur in the southern part of the county, on the waters of Clear creek, which forms the North Fork of Tradewater.

In a space of about one hundred feet there are not less than three workable beds of coal, having a united thickness of not less than fifteen to sixteen feet, viz: the Main Pigeon Run or Sisk coal, six to eight (or nine) feet thick; the Middle or Jackfield coal, four to four and a half feet thick; and the Lower Gamblin coal, four to five feet in thickness.

About fifteen to twenty feet below the main coal occurs a fourth bed, varying from one to two and a half feet, covered, in many places, by black slabs of a bituminous, ferruginous, calcareous rock, locally running into black band iron ore, interstratified in the shale covering this coal.

In the hundred feet of space above the Lower Gamblin coal is another bed of coal, varying from two to six feet in thickness—the Upper Gamblin coal.

Thus in a space of two hundred and twenty feet there are, in this part of Kentucky, five beds of coal, with an average united thickness of upwards of twenty feet, and capable of affording, if worked out, one million bushels of coal, and yielding a profit to the owners, at a minimum rate of three cents per bushel, of thirty thousand dollars. Yet this is not even all the beds of coal discovered in this part of Hopkins. On the Middle Prong of Richland creek there is still another coal, two to three and a half feet thick, which lies beneath all the preceding, under a heavy white sandstone. And it is not improbable that a detailed geological survey of the county may disclose other interstratified beds not at present known.

The main coal is conveniently exposed for mining, above the beds of the branches in many places, on Clear creek and its branches, as for instance, at the Davis bank, on Pigeon Run; at the Sisk bank, on the Hunting branch; at the Robertson bank, three-fourths of a mile west of the located line of the Nashville and Henderson Railroad; at Simons & Earl's. At these latter localities it has a roof of three feet and upwards of solid limestone, which is almost black at the most north-westerly out-crops, capable of receiving a polish, and producing a handsome black marble.

Some of the coals which crop out on the head waters of the south branch of Tradewater, in the northern part of Christian county, appear to be the lowest workable beds basseting on the south-west margin of the western coal field of Kentucky, viz: the Terry, Hamby, and Campbell coals, occupying probably an inferior position even to the lowest of the Wright's mountain section. It will require, however, a minute detailed geologico-topographical survey of this region before the true geological position of many of the out-crops of coal examined in these counties can be established.

The shaly beds which intervene between the main coal and the next over-lying or middle coal, are locally rich in argillaceous iron ore, as well as the shales over-lying the latter coal, in the body of Wright's mountain, and underlying the main coal. Their yield will be seen by consulting Nos. 130, 131, 132, and 134 of Dr. Peter's Report. Nos. 135 and 136, of the same document, shows the composition of Towns & Kirkwell, and Robertson's coal. The six other coals from this district, analyzed in my laboratory, yielded the following results:

*No.* 197. *Terry's coal, three quarters of a mile north of the southern boundary of Hopkins county, on the Bull branch of Buffalo creek, near the sources of Tradewater, three to three and a half feet thick.*

| | | |
|---|---|---|
| Specific gravity, | 1.278 | |
| Total volatile matter, | | 42.2 |
| Coke, | | 57.8 |
| | | 100.0 |

| | |
|---|---|
| Water, | 3.5 |
| Volatile combustible matter, | 38.7 |
| Fixed carbon in coke, | 54.8 |
| Ashes, (light grey,) | 3.0 |
| | 100.0 |

Has little disposition to concrete in burning; does not swell up much in coking; coke of moderate density; exhibits the woody fibre in great perfection. This is probably the lowest workable bed of coal of Hopkins county, and is supposed to be equivalent to the Hamby, Campbell, and Wooldridge coals, in Christian county.

*No. 195. Box Mountain Spring coal, Hopkins county, two feet thick.*

| | | |
|---|---|---|
| Specific gravity, | 1.339 | |
| Total volatile matter, | | 40.75 |
| Coke, | | 59.25 |
| | | 100.00 |
| Moisture, | 6.00 | |
| Volatile combustible matter, | 34.75 | |
| Fixed carbon, | 50.25 | |
| Ashes, (white,) | 9.00 | |
| | 100.00 | |

In coking it swells up considerably, forming a bright but cellular coke; coal composed of alternate bright and dull layers, with some white and ochre powder in the joints. This coal is probably the third in the ascending series of the southern side of the basin, and is the coal which is locally covered with black band iron ore, passing, however, frequently into the ferruginous calcareous rock before mentioned.

*No. 192. Main coal of the Hunting branch, Hopkins county, six to nine feet thick.*

| | | |
|---|---|---|
| Specific gravity, | 1.305 | |
| Total volatile matter, | | 45.2 |
| Coke, | | 54.8 |
| | | 100.0 |
| Moisture, | 5.4 | |
| Volatile combustible matter, | 39.8 | |
| Fixed carbon in coke, | 50.7 | |
| Ashes, (grey,) | 4.1 | |
| | 100.0 | |

This is the thickest of all the coals of the south-western coal fields at present known, and supposed to be the fourth in the ascending series. It is a bright coking coal, with thin lamellæ of selenite in the joints; it swells up but little in coking, forming a light coke of sooty aspect, with bright ramifications.

*No.* 198. *Pigeon Run coal, owned by Capt. Davis, thickness eight to nine feet.*

| | | |
|---|---|---|
| Specific gravity, | 1.283 | |
| Total volatile matter, | | 46.8 |
| Coke, | | 53.2 |
| | | 100.0 |
| Moisture, | 5.5 | |
| Volatile combustible matter, | 41.3 | |
| Fixed carbon in coke, | 49.7 | |
| Ashes, (white,) | 3.5 | |
| | 100.0 | |

This coal is considered to be equivalent, in geological position, to No. 192. About eight feet of this coal is exposed in the bed of the branch, and there appeared to be about another foot of coal under water. It has here, as elsewhere, a clay parting of two to three inches. This coal dips to the south at a considerable angle, and there seems to be a fault or slip of the strata on the north, which has brought down a four-foot bed of coal, equivalent to the Jackfield coal, so that its bottom is almost on a level with the top of coal No. 198. Between the two coals there is a fissure filled with clay, which is ten feet wide at top, and about three times that width in the bed of the branch. About two hundred yards down the branch there is another fissure, where the black shale over coal No. 198 abuts against the slip, while light grey shale occurs on the opposite side. No. 198 is covered by five feet of shale, and that by sub-soil. No limestone can be seen at this section. It has a thin clay parting of two to three inches about four feet from the top of the coal. At most localities it has a limestone roof, and sometimes, in addition, large calcareous hemispherical concretions inclosed in shale interposed between the top of the coal and the limestone, as on the Hunting branch.

*No.* 193. *Jackfield coal, owned by Capt. Davis, of Hopkins county, from four and a half to five feet thick.*

| | | |
|---|---|---|
| Specific gravity, | 1.294 | |
| Total volatile matter, | | 43.75 |
| Coke, | | 56.25 |
| | | 100.00 |

| | |
|---|---|
| Moisture, | 4.00 |
| Volatile combustible matter, | 39.75 |
| Fixed carbon in coke, | 50.75 |
| Ashes, (nearly white,) | 5.50 |
| | 100.00 |

This is the fifth in the ascending order. Not quite so bright a coal as the preceding; composed of alternate bright and dull layers; it concretes but slightly in burning; does not swell up much in coking; coke like that of No. 4.

*No. 194. Gamblin coal owned by Burbank and Dunville, situated on the head waters of Stuart's creek, four to five feet thick.*

| | | |
|---|---|---|
| Specific gravity, | 1.270 | |
| Total volatile matter, | | 42.47 |
| Coke, | | 57.53 |
| | | 100.00 |
| Moisture, | 3.40 | |
| Volatile combustible matter, | 39.07 | |
| Fixed carbon in coke, | 56.13 | |
| Ashes, (pale flesh color,) | 1.40 | |
| | 100.00 | |

This, the sixth coal in the series, is a superior coal, being rich in fixed carbon, and containing but little earthy matter. Coke bright and of moderate density; but slightly coherent in burning. Judging from this single analysis it is probably the best coal of the series for manufacturing purposes. The coal is somewhat iredescent on the surface, with thin lamellæ of sulphate of lime and ochreous earth disseminated in the joints.

On the land of Burkley Earl a coal two and a half to three feet thick underlies, with the intervention of five feet of shale, a heavy sandstone, thirty-three feet in thickness, which skirts the brow of the ridge, the rocks dipping to the north, with fine springs issuing at the base of the sandstone cliff.

It is uncertain, at present, whether this coal is the equivalent of either the upper or lower Gamblin beds, but its thickness and proximity to the sandstone would rather indicate an affinity to the upper.

A reconnoissance was made of the localities where coal occurs in Hopkins county, belonging to the above group. Gilden's coal, half a mile west of the Butter-milk road, and three miles west of the location of the railroad, is in a bed three feet two inches thick, resting on fire-clay, and covered by nine inches of grey argillaceous shale, or impure fire-clay; over this is an irregular bedded sandstone; the strata dip about 3° to the south; a thin band of iron pyrites runs on the top of the coal, and a streak through the middle, otherwise it appears to be tolerably free from impurities. It is employed both for domestic purposes and blacksmith's use in Hopkinsville.

Martin Croft's coal bank, one and a half miles north of the south line of Hopkins county, is of the same thickness as the last mentioned coal, and of similar quality. Both coals are at present only worked by stripping. They are worth from five to seven cents at the bank, and fifteen to eighteen cents when delivered in Hopkinsville.

The Franklin coal, on the Buffalo branch of Tradewater river, one and a half miles west of the Butter-milk road, measures four feet, and has a roof of shaly sandstone, with a few inches of argillaceous shale intervening. It is probable that all these coal beds are the equivalent of No. 197, lying near the base of the Coal Measures, if not the lowest workable bed of this part of the basin.

Near the line between the lands of Gordon and Davis, I examined an out-crop of coal five feet thick, covered with sheety black shale, with calcareous segregations, probably occupying the same geological position as Earl's coal, previously mentioned; and another coal, of four feet eight inches, with the same kind of black shaly roof, interposed between the coal and a bed of sandstone, in a ravine leading to the waters of Caney creek, near where the waters divide, flowing west into Tradewater, and east into Pond river. A few hundred yards below, on the same branch, soft argillaceous shales, with two harder bands interstratified, are exposed to the height of thirty-five to forty feet, overlaid by thin bedded sandstone, all dipping about 20° south-east. At a higher level abrupt ledges of heavy sandstone form the descent from the upland farms to the creek bottoms, which appear to occupy the same geological position as the massive sandstone over the Gamblin coal; beneath this springs of chalybeate water issue, one of which I had occasion to examine on the property of Alfred Townes.

Numerous out-crops of coal occur within a short distance of the line of the Henderson and Nashville railroad, around the base of Wright's mountain and its spurs, near the sources of the streams flowing into Tradewater and Pond river. Besides those already noted I had an opportunity of inspecting the following: On the head branch of Richland creek, there is a five-foot coal, covered with two and a half inches of black sheety shale, equivalent probably to No. 194. It is a bright looking coal, with thin laminæ of pyrites running in some of the joints. Here I also observed some fifteen to twenty feet of shale, with ironstones disseminated, in the space about eighty feet below the coal, and a band of carbonate of iron forty to fifty feet higher. Beneath the whole of these shales and ironstones there is the feathered edge of shale and coal, which is probably the equivalent of No. 195. The top coal is overlaid by shaly sandstone, running upwards into heavier bedded sandstone, to the height of fifty-five feet, which corresponds, in geological position, to sandstone overlying coal No. 194.

The "Box Mountain Sulphur Spring," on the property of Mr. Alfred Townes, west of Todd's Gap, and half a mile from the railroad, flows out from the geological horizon of the Box mountain coal, No. 195, through a fissure in slabs of the aforementioned black ferrugino-calcarious rock. Tested qualitatively at the fountain head with re-agents, its principal constituents were found to be

Free sulphuretted hydrogen,
Bi-carbonate of lime,
Bi-carbonate of magnesia,
Chlorides of sodium and magnesium,
Sulphate of magnesia,
Sulphate of soda? or potash? and
Carbonate of soda or potash; as it has an alkaline re-action after being boiled down and the excess of carbonic acid expelled.

It produces a pink sediment, which subsides on the surface of the gum. The temperature of the water was 63° Fahrenheit, while the temperature of the air at the same time was 90°.

Iodine and bromine were not tested, as it required for this purpose that the water should be concentrated, and more refined operations than could be resorted to in the field.

On the head waters of the southern branch of Clear creek, in Merridy's Gap, there is an out-crop of coal three hundred yards west of the Madisonville road, which appears to be over five feet, as far as could be ascertained from the imperfect section obtained.

At the south-east bank on the Hunting branch of Clear creek, one to three-quarters of a mile east of the railroad, coal equivalent to No.

191 is exposed, on the lands owned by Mr. Sisk, dipping some 5° to the N. or N. E.,* with a portion of its base in the bed of the creek. Seven feet of coal can be seen, with a clay parting of one to two inches, four feet three inches from the top. Beneath the clay parting there are from three to four feet more coal. Over the coal are four and a half feet of black shale, with calcareous segregations in huge flattened spheroids; over this, two and a half feet of grey limestone. Two thin pyritiferous bands run through the coal, about two and a half feet from the top.

This coal, in 1854, was worth five cents at the bank, and eight cents delivered in Madisonville.

The same bed shows itself about one hundred yards to the west, on the property of the Madisonville Coal Company, known as the Tallifarro Bank. Sandstone appears to replace the limestone; at least none can be seen here over the coal; only the black shale inclosing septaria. The dip here is from 3° to 4° to the N. E. The clay parting occurs here at the same distance from the top—four feet three inches. Two feet three inches more coal can be seen down to the water level. At the Wollfolk opening six feet one inch of coal is seen, of which four feet is above the clay parting.

By analysis the Lick coal (No. 192 of the collection) yielded,

| | | |
|---|---|---|
| Specific gravity, | 1.305 | |
| Total volatile matter, | | 45.2 |
| Coke, | | 54.8 |
| | | 100.0 |
| Moisture, | 5.4 | |
| Volatile combustible matter, | 39.8 | |
| Fixed carbon in coke, | 50.7 | |
| Ashes, (grey,) | 4.1 | |
| | 100.0 | |

A bright coal; bituminous coke; disposed to cake in burning. Thin lamellæ of sulphate lime (selenite) in the joints.

On the Hunting branch there are two other beds; one which is estimated to lie nine to fifteen feet below the level of the creek, and another about the same distance above the Main coal; so that we have here three beds of coal in a space of forty to fifty feet; these are equivalent to the beds Nos. 192, 195, and 198 of the collection.

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* The prevalent dip of the Hunting branch is propably N. W.

At Bunt's Gap are thick ledges of sandstone similar to that near B. Earls', under which a corresponding series of coals may be expected to be found. In this vicinity, towards the summit of Barnet's Hill, a coal occurs overlaid with a red ochre, similar to that observed in the vicinity of coal No 193. This is two and a half miles south, 45° west of the Jackfield coal.

On the head of Pleasant run a coal five-foot, or more, in thickness is seen, overlaid by solid black shale, with grey shale and ironstone superimposed, probably including also a bed of coal, over which, at an elevation of seventy-five feet, is limestone underlying sandstone. A similar section of a five-foot coal, covered by shale and ironstones, is seen near the head of Fox run, a branch of Caney fork of Tradewater, in the Box mountain, the whole resting on fire-clay and argillaceous shale, with large septariæ. This is one mile and a quarter west of the railroad, or about three miles by the course of the valley; this, and the Woodson & Gordon coal, on Richland creek, are probably the equivalent of coal No. 193.

On Cane run, coal, occupying the geological position of 195, is seen, with a roof of ten feet of shale, enclosing four to six inches of black bituminous ferruginous limestone.

The "slate quarry," marked on the map of Hopkins county, on Richland creek, is merely solid, sheety, black bituminous coal shale, splitting into large square slabs, occupying the geological horizon of the roof either of coal Nos. 195 or 192, concealed beneath the bed of Richland creek. It is not sufficiently durable to answer the purpose of a roofing slate, as it not only warps in the sun, but is subject to split and scale up by exposure to the weather.

Three quarters of a mile above the Woodson & Gordon bank, on Richland creek, a coal of five feet in thickness, with a floor of fire-clay, and a roof of shale, considered referable to coal No. 195; and about one hundred feet higher, and half a mile from the divide between Caney and Richland creek, Edward Wright has opened a coal bank; and on the land of George Wright, on the middle prong of Richland creek, one and a half to two feet of coal is to be seen, underlying thick-bedded white sandstone, of ten feet or more; and the same bed was struck in digging Richard Wright's well, half a mile west of Wright's mountain, and some eighty or one hundred feet below its base, where it is two feet thick, with four feet of sandstone over it. This is one of the lower coals of Hopkins county, but whether identical with No. 197 or not, is, as yet, uncertain.

On the head waters of Stuart's creek, two hundred feet above the railroad, coal is found equivalent to No. 195, covered with shale, including a band of black bituminous ferruginous calcareous rock, No. 132, analyzed by Dr. Peter—(see his Report.) The same formation appears to prevail in the low gap between Stuart's creek and Sugar creek—see specimen No. 133 of Dr. Peter's Report; and also twenty feet below the summit level of Towne's Gap, on the west spur of Wright's mountain, near the western survey of the railroad, as well as on the north-east branch of Richland creek.

Coal also occurs at A. Earl's, and one mile above, at Martin Hall's, at the junction of Stuart's and Clear creeks; on the Sulphur fork of Flat creek, and on Dozier mountain, on the waters of Fox creek.

On Flat creek, at station 464 of the railroad line, thirty feet lower than Box mountain spring, carbonate of iron occurs in shale, associated with black bituminous ferruginous limestone, with about eighteen inches of imperfect coal or coal brash overlying the latter rock, indicating a dip of thirty-one feet in three quarters of a mile, in a direction south 75° east. Shale is seen also in the bed of a branch one and a half miles south 20° east of the Tunnel, probably occupying the same geological position.

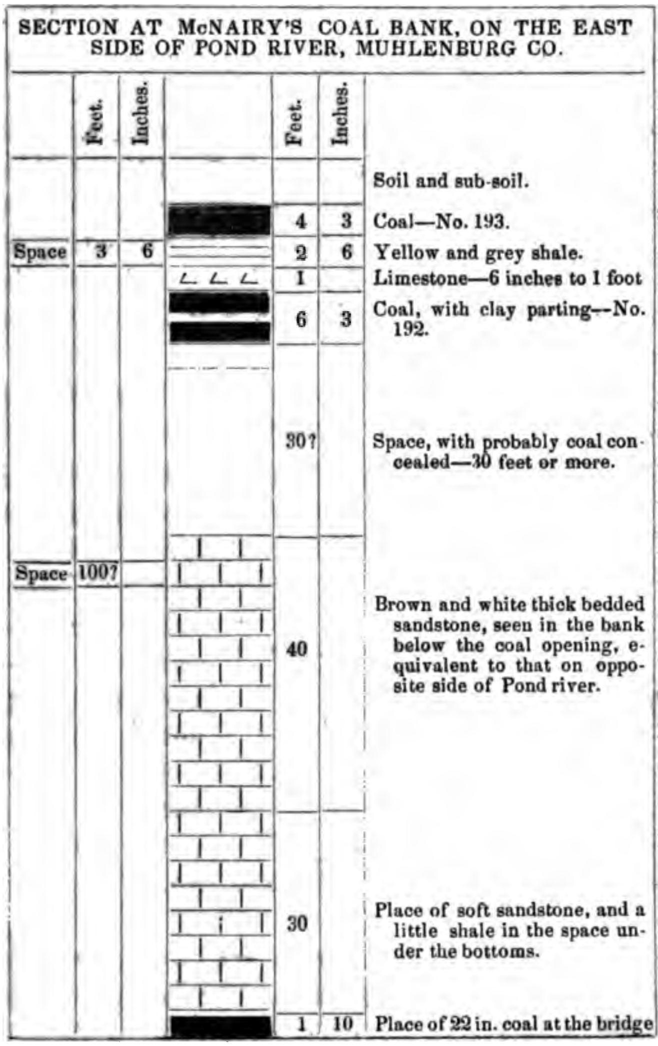
At Machadoo Lick, on the east side of Flat creek, is a great bed of shale, with black bituminous ferruginous calcareous rock, with probably a bed of coal under it; and a similar formation is seen where the railroad crosses Todd's gap.

A thick coal bed (six or seven feet,) occurs on the Bailey hill, dipping south-east 3° to 4°, now owned by the Box mountain company, which is supposed to be equivalent either to coal No. 194 or No. 192; and two out-crops, one of which is probably the same bed, occurs on Bell's Knob. In this hill the grey shales contain considerable masses of clay ironstone, and the yellow shales are charged with a red ochreous iron ore.

On Pond river, a few yards from the foundation of the bridge, where the Madisonville and Greenville road crosses that stream, a bed of coal eighteen to twenty inches in thickness is exposed, near low water of that stream. The immediate covering is soft yellow sandstone, and a few inches of shale, while thirty feet above the bed of Pond river, a cliff of forty feet of brown and white sandstone, some of it micaceous, forms a mural escarpment, skirting the narrow bottom of this stream on the west, the lower portion having the cross-lines of deposition characteristic of the millstone grit, at the base of the Coal Measures, but, so far as it was examined, without pebbles. For an analysis of this coal see No. 137, of Dr. Peter's Report.

Across the bottom, on the opposite side of Pond river, in Muhlenburg county, on the property of Mr. McNairy, at an elevation of seventy feet above high water, the following interesting section is exposed, of coals Nos. 192 and 193:

SECTION AT McNAIRY'S COAL BANK, ON THE EAST SIDE OF POND RIVER, MUHLENBURG CO.



|  | Feet. | Inches. | Feet. | Inches. |  |
|---|---|---|---|---|---|
|  |  |  |  |  | Soil and sub-soil. |
|  |  |  | 4 | 3 | Coal—No. 193. |
| Space | 3 | 6 | 2 | 6 | Yellow and grey shale. |
|  |  |  | 1 |  | Limestone—6 inches to 1 foot |
|  |  |  | 6 | 3 | Coal, with clay parting—No. 192. |
|  |  |  | 30? |  | Space, with probably coal concealed—30 feet or more. |
| Space | 100? |  | 40 |  | Brown and white thick bedded sandstone, seen in the bank below the coal opening, equivalent to that on opposite side of Pond river. |
|  |  |  | 30 |  | Place of soft sandstone, and a little shale in the space under the bottoms. |
|  |  |  | 1 | 10 | Place of 22 in. coal at the bridge |

Here we have the singular phenomenon of two thick coals within three feet and a half of each other, and no doubt from thickness, the occurrence of the intervening limestone and the clay parting in the six-foot coal, the equivalent of No. 192 and 193 of Hopkins county, which here, about their southern limit, nearly run together with only a few feet of earthy material intervening.

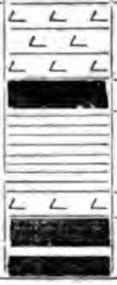
The shale over the upper coal, which may be seen where the bluff is higher, has much argillaceous iron ore disseminated. The underlying coal has, at some time, been on fire, and has run the ferruginous shale into a cellular rock, having very analagous structure to certain volcanic products. The limestone thins to the north, and thicken to the south. The dip appears to be east or north-east.

On a branch half a mile to the south-east of the above locality, a bed of coal appears, partly covered with water, supposed to be three or four feet in thickness, overlaid by shale. It is, as yet, uncertain whether this is a coal which comes in the thirty feet of space, under the six-foot coal, which may have been brought here within ten or fifteen feet of high water by a slip or fault. There appears to be a dislocation of the strata with a change in the dip between this and the previous locality.

Thirty-five feet above this last out-crop, in a direction south-east, coal again makes its appearance, perhaps equivalent to No. 194, of Hopkins county; and a half mile still further to the southeast, coal with a clay parting, under limestone, shows itself as at the first locality at McNairy's bank. The limestone is two feet ten inches to three feet in thickness, and the coal about five feet. The dip here appears to be about 2° to the south-east.

At Clark's mill, near high water of Pond river, below the Forks, a section very analagous to that at McNairy's bank, occurs:

SECTION ON POND RIVER, AT CLARK'S MILL, NEAR HIGH WATER.

| | Feet. | Inches. | | Feet. | Inches. | |
|---|---|---|---|---|---|---|
| Space | 10 | |  | | | Argillaceous shale, with clay iron stone. |
| | | | | 2 | | Coal. |
| | | | | 10 | | Shale. |
| | | | | 2 | | Limestone. |
| | | | | 5 | | Coal, with clay parting. |

In a ravine to the east the two feet of coal, covered with shale and ironstone, again crops out—a spring issuing from between the overlying shale. For an analysis of this coal see No. 158 of Dr. Peter's Report.

The soil in the vicinity of the above described coals is rich, but the surface is considerably broken. As a general rule the northern slopes conforming to the plane of dip of the Coal Measures, are better sites for farms, in Hopkins and Muhlenburg counties, than on the southern slopes, where the strata bassett, which are generally poorer, more uneven and rocky. Two miles south of McNairy's, and one and a half to two miles east of Pond river, a thick coal (six or seven feet)—the Marcus coal—is said to occur, situated some four or five feet above the bed of a branch. Four miles east of McNairy's a two foot coal—the Stanley bank—lies between sandstone, low on Isaac's creek, five miles above its mouth, probably equivalent to the twenty-inch coal at the bridge on Pond river.

On the right bank of Pond river a coal, on the property of George Eaves, is partially exposed near low water, covered by grey shale, with thin layers of sandstone intercalated, eight feet of which is seen in the bank of Pond river. The thickness of the coal could not be seen—it is said to be from four to four and a half feet. The roof is very similar to that of the Roberts coal, on Muddy river, but the identity of this coal is at present uncertain.

On the waters of Isaac's creek, on the property of Mr. Miller, coal six feet two inches, (equivalent to No. 192,) with a clay parting as usual, two feet from the bottom, underlies one and a half feet of limestone, with the interposition of eight inches of shale between the coal and limestone. The same bed occurs also three quarters of a mile to the north-west, overlaid by limestone; also, one mile to the east, on the property of the heirs of the widow Woods. Seventeen feet of a soft white sandstone was passed through in digging Mr. Miller's well. A spring comes out amongst sandstone near his house, very probably from the place of a coal of the same date as No. 194, or that overlying it.

In a hollow, at the foot of Capt. Wing's lot, in the town of Greenville, a refractory, hard, brecciated limestone, seven to eight feet thick, appears in rugged ledges, overlaid by soft sandstone, with the intervention of some black dirt, indicating the place of a thin coal. This is probably a limestone which comes in under the sandstone below coal No. 194; the limestone a mottled dark grey and yellow, and would no doubt take a good polish, but is very refractory to work and get out in good form.

On a hill-side, south of Greenville, eight inches of coal is seen, covered by shale and schistose sandstone, occupying, perhaps, the place of the coal dirt over the limestone in the town of Greenville.

North of this place, a mile and a half to two miles, a four and a half-foot coal has been opened by Mr. Eaves, covered by two to three feet of black shale. This coal corresponds, probably, in geological position to coal No. 193, of Hopkins county, but it has here a duller aspect, and is more brittle than it is further west. A buff limestone rises from beneath this coal, and is seen in a hollow to the south of the mine.

Three miles west of north of Greenville is the Martin coal, covered by solid limestone, and with the usual clay parting of coal No. 192. It dips about 8° east of north. In a ravine on the Weir and Ricketts place, three miles northwest of Greenville, a section is exposed of about one hundred and forty feet of strata, including at least three beds of coal, as follows:

| | *Feet.* |
|---|---|
| Thirty feet below top of ridge coal, | 2 |
| Space, | 15 |
| Coal under limestone, | 1? |
| Space, with fire clay shale and heavy sandstone, | 90 |
| Coal, (equivalent to No. 194?) | 5 |

On top of a hill about one hundred feet high, one mile and a half west of Greenville, shale, with Kidney iron ore (No. 145 of Dr. Peter's Report) occur; in all about fifteen feet thick; under this, impure grey limestone, twenty feet? in thickness; resting on clay shale twenty-five feet; under this, laminated shale, with a band one and a half inches thick, of black bituminous, ferruginous limestone, inclosed in two feet of black, indurated, slaty shale, resting on shaly sandstone, where there has been an attempt to search for lead ore. No coal is visible in this section, though the place of coal No. 195 appears to be under the black indurated shale, But if so the overlying coals appear to have feathered out; at least they were not discovered.

Two and a half miles south-west of Greenville three feet of coal shows itself, having a northerly dip, two to three feet above the bed of the branch, known as the Eades coal, overlaid by four feet two inches of black bituminous shale and imperfect coal; then ten inches of grey argillaceous shale; the whole being surmounted with a heavy sandstone. For an analysis of this coal see No. 157 of Dr. Peter's Report.

This coal presents some iridescent hues, and contains thin lamellæ of sulphate of lime in the joints.

On the waters of Battist creek, south side of Pond creek, several miles south of Greenville, two feet of slaty black band iron ore is in place—No. 150 of Dr. Peter's Report—yielding 36.5 per cent. of metallic iron. It reposes on black shale, and is overlaid by four feet of argillaceous shale, including iron stone, with a capping of one and a half feet of sandstone. The black shale under the ore is five to six feet thick, and covers a bed of coal of two and a half feet in thickness, equivalent to No. 195? These ores, together with ore from the Jenkins ore bank, two and a half to three feet in thickness, (No. 146 of Dr. Peter's Report,) yielding 43.56 of metallic iron, are the ores which were used at the old Buckner furnace when in blast. The discontinuance of the operations of this furnace was not due to any deficiency or defect in the ores, but for want of capital, and from the bad construction of the stack, which was entirely of too large a diameter for the blast.

A fossiliferous iron of several feet in thickness, also worked at the furnace, was obtained on ridges on the waters of Lick creek, one and a half miles south-east of the site of the furnace. The Jenkins ore bank lies four miles south-east of the furnace, twenty feet above the waters of Battist creek. It required from ten to twenty feet of stripping to uncover the ore. The grey limestone used as a flux was obtained one mile south of the furnace. It seems to belong to the subcarboniferous limestone. The hearth stones were procured one and a half miles east of the furnace. Both the analysis of the ores, the thickness of the ore beds, and proximity of all the necessary materials, with an ample supply of forest timber, all indicate a favorable position for iron works; especially if by the construction of a railroad through Muhlenburg county to the Ohio river a more direct line of communication to a market were established.

In Ford's well, on the waters of Pond creek, at a depth of twenty-five feet, a black band iron ore was reached—No. 151 of Dr. Peter's Report—yielding 36.8 per cent. of metallic iron. It is represented as being nineteen inches thick, resting on black shale, as No. 150 does, on Battist creek, which is two miles east of Ford's; both no doubt occupy the same geological position, as well as ore No. 152, yielding 31.17 of metallic iron, found between Turner's and the old Buckner iron works. If this ore is as thick as is represented, and throughout of a quality equal to the specimen analyzed, it is not only a most important deposit of this valuable variety of iron ore, but affords evidence of a very extensive distribution, in Muhlenburg county, of this species of ore, interstratified or disseminated in the shales overlying coal equivalent to No. 194, of Hopkins county.

On the waters of Pond creek, in the same neighborhood, a three-foot coal, underlying sandstone and resting on fire-clay, appears, both at Turner's and at Walker's, one and a half miles west of Turner's. This is one of the lowest workable beds of Muhlenburg county, probably equivalent to No. 197 and No. 137. These southern and lower coals of Muhlenburg are preferred by the blacksmiths, to those north of Greenville. As yet we have no analysis of this coal in Muhlenburg county.

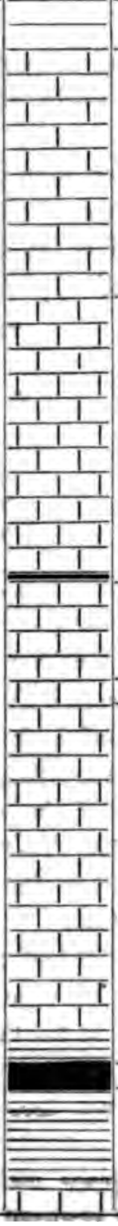
The above are some of the principal localities of which a geological reconnoissance has been made, in the middle part of Muhlenburg county, up to the present time; a great deal remains, however, to be developed in regard to these Coal Measures, both rich in coal and iron ore.

I proceed now to notice my observations in the eastern part of Muhlenburg county, along Muddy and Green rivers.

One of the most important and accessible coals on Muddy river, is the bed now owned by the Green River Coal, Iron, and Manufacturing Company, formerly known as the Roberts' coal, which bassetts twenty feet above low water of that stream, ten miles above its mouth, and five miles in a direct line from Lock and Dam No. 3. It measured three feet ten inches at the face of the drift, when I was there, the lower two-thirds being a fine, bright, solid "block" coal, having a cuboidal cleavage, but little disposed to crumble in mining and handling, nor to disintegrate by exposure to the atmosphere. It has a shale roof, and a floor of dark grey ferruginous argillaceous shale, including nodules of clay iron stone. There is a wave in the Coal Measures at this locality, since the coal in the entry has a southerly dip of about four feet in three hundred and fifty feet, while it takes a rise a short distance below, and about one mile to the south the conglomerate is said to be in place.

The section of the bluff in which the coal is found, as far as can be seen, is as follows:

SECTION OF BLUFF AT THE MINES OF THE GREEN RIVER COAL, IRON, AND MANUFACTURING COMPANY; 172 FT. FROM RIVER TO DR. ROBERTS' HOUSE



| | Feet. | Inches. | Feet. | Inches. | |
|---|---|---|---|---|---|
| | 160 | | | | Soil and sub-soil. |
| | | | 40 to 50 | | Thick bedded sandstone, forming a cliff towards the tops of the ridges. |
| | 105 | | | | Place of coal, at 205 feet, at Porter's landing? |
| | | | 36 | | Schistose micaceous sandstone. |
| | 69 | | | | Thin coal. |
| | | | 10 | | Shaly sandstone. |
| | 59 | | | | Band of gritstone. |
| | | | 37 | | Schistose micaceous sandstone. |
| | | | | | Shale. |
| | 20 | | 3 | 10 | Main coal of Muddy. |
| | | | | | Slope concealed, including shaly rock? |
| L. W. | | | | | Sandstone at low water. |

The main block coal, twenty feet above Green river, at these mines, is supposed to be inferior in position to the coal overlaid by black band, passed through in the borings at Williams' landing.—If so, it would come in near where the thin coal is represented, at about seventy feet above the river, and fifty feet above the main coal. The space below the sandstone cliff and the main coal appears to represent the strata much reduced in thickness where the thick coals of Hopkins and the middle part of Muhlenburg counties belong; but which have thinned and feathered out near the confines of the coal basin on

Muddy river. This inference is rather confirmed, if it be true, that there are three coals crowded into twelve feet of space in the bluffs of Green river, about two miles above its mouth, at about the required level. These are, however geological problems, that can alone be solved satisfactorily by a minute geologico-topographical survey, such as has been made of Union county.

At these mines, with the present drift, one man can get out about seventy to seventy-five bushels of coal per day, worth, at the mines, six cents per bushel.

There is slack-water navigation on Muddy river, from its mouth to the coal entry, with a depth of six feet of water if cleared of obstruction.

The chemical analysis of the block portion, i. e. two-thirds of the lower part of Roberts' coal, No. 191 of the collection, yielded:

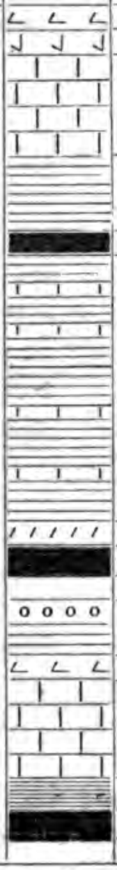
| | | |
|---|---|---|
| Specific gravity, | 1.218 | |
| Total volatile matter, | | 41.48 |
| Coke, | | 58.52 |
| | | 100.00 |
| Moisture, | 5.00 | |
| Volatile combustible matter, | 36.48 | |
| Fixed carbon in coke, | 54.72 | |
| Ashes, (white,) | 3.80 | |
| | 100.00 | |

It is slightly coherent when ignited, and burns with a strong yellow flame, free from sulphurous acid or sulphuretted hydrogen. It swells up slightly in coking, and leaves a bright coke, above the medium density of that obtained from the coals of the western coal field of Kentucky. It will, doubtless, prove to be one of the best for manufacturing purposes on the waters of Muddy river. There is another coal supposed to be in the bed of Muddy river, below the main coal, but nothing definite is at present known in regard to it.

At Van Landingham's, on Green river, one and a half miles below Lock and Dam No. 3, hard layers of sandstone are seen, extending from low water for eleven feet, (with coal under it in the bed of Green river?) This sandstone dips obliquely across Green river, at an angle of 3° to 4° to the north-west, or about five to seven feet in one hundred feet.

Near Campfield's, and I believe also at this place, coal two and a half to three feet thick, having the appearance of charcoal, lies thirty-five feet above the river, covered by shale and a grey band. This is, probably, the representative of coal No. 194, and if so, that reported in the bed of Green river at this place is the equivalent of Roberts' coal; but if so, the sandstone overlying it is harder and more solid than on Muddy river. A coal dirt also appears in the bank of Green river, at Van Landingham's, eighty-two feet above low water, and sandstone ledges at one hundred and twenty-six feet. This coal probably occupies the place of No. 193. The shaft and borings put down here by Mr. Kurzman, at Williams' Landing, disclose the following section:

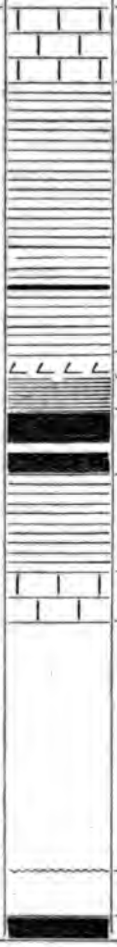
SECTION AT WILLIAMS' LANDING, COMMENCING FIFTY FEET ABOVE GREEN RIVER; SPACE ABOVE BORINGS FILLED WITH SANDSTONE, UNDERLAID BY SHALES CONTAINING IRON STONES.



|  | Feet. | Inches. | Feet. | Inches. |  |
|---|---|---|---|---|---|
|  |  |  | 3 |  | Limestone. |
|  |  |  | 3 |  | Iron ore. |
|  |  |  | 15 |  | Sandstone. |
|  |  |  | 15 |  | Shale. |
|  |  |  |  | 8 | Coal, 8 inches, said to be 4 feet on Pond creek. |
| L. W. Space. | 59 |  | 58 |  | Hard bands of sandstone, interstratified with argillaceous shales and some iron stones. |
|  |  |  | 1 | 1 | Black band. |
|  |  |  | 2 | 6 | Coal, brash. |
|  |  |  | 4 |  | Fire clay. |
| Space. | 33 | 6 | 6 |  | Iron balls and bituminous shale |
|  |  |  | 3 | 6 | Hard calcareous rock, contain-pyrites. |
|  |  |  | 15 |  | Sandstone. |
|  |  |  | 5 |  | Bituminous shale. |
|  |  |  | 3 | 6 | Block coal. |
|  |  |  |  |  | 60 feet below this no coal reported. |

The dip is about 5° 30′, or eight feet in one hundred, to the north-west. The block coal struck at the bottom of the section here given, is supposed to correspond to the main Roberts coal, on Muddy river; but to determine this positively would require minute surveys of horizontal distances and dip.

At Airdrie, now the property of R A. Alexander, formerly known as Paradise, and so designated on Milne's map, the main coal, No. 192, with its clay parting and limestone roof, lies seventy feet above Green river, known formerly under the name of the McLean coal. It measures here six feet to six feet two inches; it is covered by three feet nine inches to four feet six inches of bituminous shale, interposed between the top of the coal and the limestone. The section is as follows:



| | Feet. | Inches. | Feet. | Inches. | |
|---|---|---|---|---|---|
| | | | | | Sandstone near top of hill. |
| | | | 45 | | Shale rocks, with argillaceous iron stone. |
| | | | | | Place of coal No. 193; not seen, but said to occur lower down Green river. |
| | | | 3 | | Limestone |
| | | | 3 | 9 | Bituminous shale. |
| Above L. W. | 70 | | 6 | | Main Airdrie coal, with clay parting. |
| | 50 | | | | Sandstone, 50 feet above low water of Green river. |
| | | | | | Space, with rocks concealed, and place of coal? No. 195? |
| L. W. | | | | | Green river. |
| | | | | | Coal? beneath river. |

For an analysis of the main Airdrie coal, see Dr. Peter's Report, No. 156.

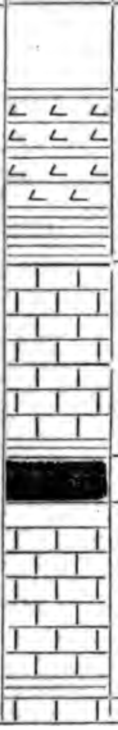
From Airdrie, towards mouth of Pond creek, the strata seems to have a gentle elevation, so that a lower coal notseen at Airdrie is said to rise above the level of the river, four miles below, overlaid by sandstone. This locality I had not, however, an opportunity of inspecting.

On Mr. Rodes' farm a limestone, with coal dirt under it, is seen in one of his fields, forty-three feet above high water; and fifty-four above high water, in a hollow above the field, there is indication of another coal, probably the equivalent of the Eaves coal, which would come in, therefore, eleven or twelve feet above the main Airdrie coal, occupying nearly the same position with relation to that coal as the Jackfield coal does to the Pigeon run coal, in Hopkins county, and the Martin and Eaves coal, near Greenville.

On high ground, near a meeting house between Airdrie and Rhodes' farm, a coal was seen, which is probably equivalent to No. 194.

At Kincheloe's bluff, or Lewisport, the rocks dip north-west about 5°. Here, at an elevation of twenty feet above Green river, coal of six feet nine inches lies under a heavy sandstone thus:

91. LEVEL OF STONE ABOVE LOW WATER OF GREEN RIVER.



| | Feet. | Inches. | Feet. | Inches. | |
|---|---|---|---|---|---|
| | | | 12 | | Soil and sub-soil, &c. |
| | 85 | 9 | 25 | | Shales, including hydrated oxyde of iron towards the top of the beds. |
| | 60 | 9 | 34 | | Thick-bedded sandstone. |
| | | | | | A few inches of shale. |
| | 26 | 9 | 6 | 9 | Kincheloe bluff coal. |
| | 20 | | 17 | | Slope, with soft shaly sandstones ? |
| L. W. | | | 3 | | Solid beds of sandstone. |

This is, probably, a coal contemporaneous with that two hundred and five feet above Green river, at Porter's Landing, (Taylor's bank,) and probably the representative, in this part of the basin, of either the upper or lower Gamblin coals, of Hopkins county; but, if so, increased in thickness and altered in quality. It is a friable coal, intersected with numerous fissures, the joints coated with ochreous infiltrations, about as thick as past-board. The specimen of this coal in the State collection is numbered 196.

Two analyses of this coal yielded,

Specific gravity, - - - - - - - - 1.273

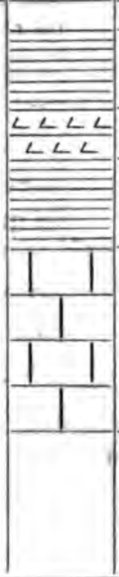
| | 1st. | 2nd. |
|---|---|---|
| Total volatile matter, - - - - - - - - - | 43.0 | 44.8 |
| Coke, - - - - - - - - - - - - - | 57.0 | 55.2 |
| | 100.0 | 100.0 |

| | 1st. | 2nd. |
|---|---|---|
| Moisture, - - - - - - - - - - | 6.0 | 4.5 |
| Volatile combustible matter, - - - - - | 37.0 | 40.3 |
| Fixed carbon in coke, - - - - - - | 55.0 | 52.2 |
| Ashes, - - - - - - - - - - | 2.0 | 3.0 |
| | 100.0 | 100.0 |

These analyses indicate a better coal than would be anticipated by inspection of the coal in place—the ashes amounting only to from two to three per cent., while it has an average quantity of fixed carbon.

At South Carrollton the Kincheloe bluff coal appears to be concealed in the river bottom, and limestone appears at an elevation of seventy feet, thus:

SECTION AT SOUTH CARROLLTON, BELOW THE TOWN.

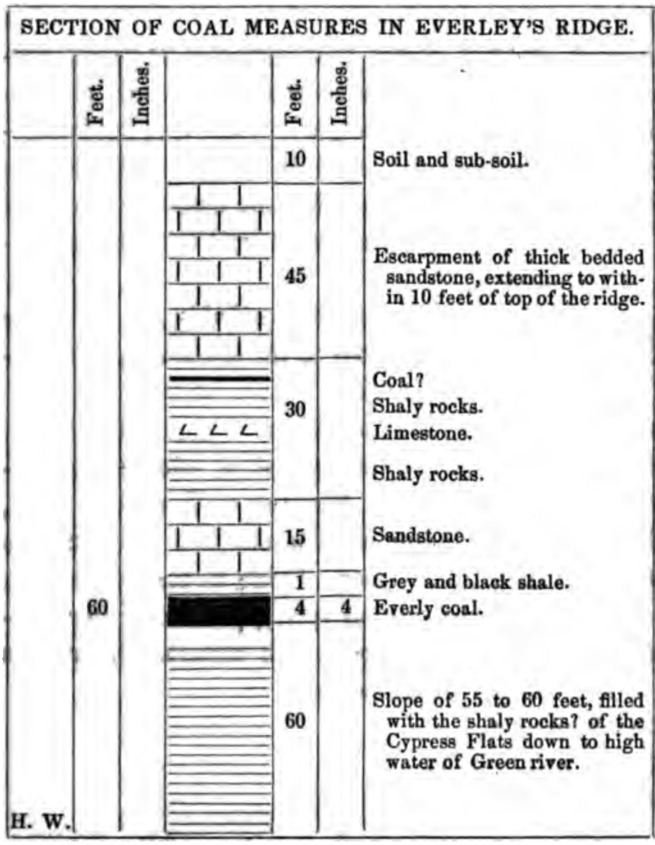


| Feet. | Inches. | | Feet. | Inches. | |
|---|---|---|---|---|---|
| 80 | | | | | Subsoil. |
| | | | 15 | | Partially disintegrated ferruginous shales, with sandy layers. |
| 70 | | | 6 | | Encrinital limestone. |
| | | | 15 | | Spring slope, with shaly rocks. |
| 53 | | | 33 | | Heavy bedded freestone, used for building purposes. |
| | | | 20 | | Rocks concealed in slope below bottom of sandstone and the river level. |
| 20 | | | | | |

The strata have here a northerly dip of about 5°. The thick bedded sandstone commencing at twenty feet above the river in this section, and extending to fifty-three to fifty-five feet, is either the heavy sandstone over the Kincheloe coal, or a higher bench of sandstone that overlies the ferruginous shale at eighty-five feet in the Kincheloe bluff section.

A heavy mass of shales succeed in the ascending order, above the South Carrollton section; these form the extensive flats and pondy region in the so-called "Island District," on the head of Cypress creek, and seem to prevail nearly to the mouth of that creek, but probably broken through by abrupt dislocation of the strata somewhere near Livermore, since the millstone grit and sub-carboniferous limestone can be seen bursting through the Coal Measures on the waters of Barnett's creek, in Ohio county, dipping 35° with a direction south 20° to 25° east, while the millstone grit on the top of the hill, east of the same creek, has a nearly reverse dip of north 30° west, at an angle of 27°. It is an extension of this same disturbance through the southern part of Muhlenburg county, which has reversed the inclination of the Coal Measures in Everly's ridge, in the "Island District," to a dip of 4° to the south, and again brought up a coal corresponding to that of Kinchloe's bluff, to an elevation of about sixty feet above high water of Green river, thus:

SECTION OF COAL MEASURES IN EVERLEY'S RIDGE.



| | Feet. | Inches. | Feet. | Inches. | |
|---|---|---|---|---|---|
| | | | 10 | | Soil and sub-soil. |
| | | | 45 | | Escarpment of thick bedded sandstone, extending to within 10 feet of top of the ridge. |
| | | | 30 | | Coal?<br>Shaly rocks.<br>Limestone.<br>Shaly rocks. |
| | | | 15 | | Sandstone. |
| | | | 1 | | Grey and black shale. |
| | 60 | | 4 | 4 | Everly coal. |
| | | | 60 | | Slope of 55 to 60 feet, filled with the shaly rocks? of the Cypress Flats down to high water of Green river. |
| H. W. | | | | | |

The four foot four inch coal under sandstone, seventy feet above Green river, two miles above Livermore, on the east side, is probably the equivalent of the Everly coal, as well as the coal struck in the wells near Worthington.

It is more than probable that the Barnett's creek dislocation above mentioned may be a continuation of the Bald Hill disturbance, of Union county, which may be traced through Muhlenburg and Hopkins counties, but lies low in the former county, under the Cypress flats; the line of fracture passing probably near Judge Eaves' sulphur spring, and crossing Pond river somewhere near the Fish Trap ford.

Through the "Island District" there is a fine body of arable land, occupying knolls and gently rolling swells, elevated thirty to fifty feet above the flats. The soil is of the nature of the fine loams of the quaternary deposits of the Jackson Purchase, only rather more argillaceous, supporting a heavy growth of Beech, intermixed with Poplar and Hickory, with an undergrowth of Pawpaw, *Annona triloba*.

The "Thoroughfare," lying between Green river and Cypress creek, is heavily timbered with Gum, White Oak, &c. It would make fine meadows, and would yield fine crops of corn, but is not in cultivation from being subject to overflow.

An extensive, low, narrow gravel bank circumscribes the flats of Cypress. Its course, from the lower part of that stream, runs through McLean and Muhlenburg counties, keeping from one to three miles distant from Pond river, until it crosses that stream at Millport, running thence from one to three miles, on its west side, until it again reaches Pond river at Ashbysburg. This gravel bank has, undoubtedly, been transported by currents established in the ocean at the time of the above mentioned disturbance, which rent assunder the Coal Measures in this vicinity, bringing the millstone grit and sub-carboniferous limestone to the surface.

At Davies' ridge sandstone and limestone, probably of the same date as those at South Carrollton, are tilted to the south-east, at an angle of 10° to 15°, by the uplift in question.

This Davies' ridge sandstone, which is fifteen to twenty feet thick, affords an excellent freestone for building purposes, and lies conveniently for quarrying. The limestone is here two to three feet thick, underlaid by yellow shales, including argillaceous iron ore; and the same limestone crops out in a field opposite Judge Eaves' house. In the hollow below his house, is the sulphur spring previously mentioned. Tested at the fountain head the "Social Hill Mineral Water" was found to contain, as its principal constituents:

Free sulphuretted hydrogen,
Bi-carbonate of soda and potash?
Sulphate of soda,

A little chloride of sodium, and probably
Sulphuret of sodium?*

After being boiled down it effervesces freely with acids, and turns reddened litmus paper blue. It contains less lime than is usually found in ordinary well and spring water. It is, no doubt, a valuable water for the cure of diseases of the skin, tinea capitis, psora, chronic pectoral affections, as an anti-lithic, and a gentle laxative, and therefore beneficial in improving the general health in many chronic affections.

On the north side of the above fault, towards the mouth of Cypress creek, dark shales and ironstones, including a bed of coal two and a half feet in thickness, basset in the banks of that stream. Fifteen feet of black shale, overlaid by ten feet of light grey shale, with clay ironstone, appear on the right bank of Green river, at the Livermore landing; under the black shale there is said to be an eighteen-inch coal under the bed of the river. These shales, ironstones, and coal are supposed to be of the same date as the shales, ironstones, and coal seen near low water of the Ohio river, at Coal Haven, and near the head of French Island, but this is, as yet, uncertain.

At Mr. Samuel's, in the north-east part of McLean county, on Deer creek, about six miles above its mouth, three coals occur in a distance of eighty feet—the upper, two and a half feet, the lower, a thick coal struck at the bottom of the boring, reported five feet or more. But if this coal series should prove to be, as seems likely, from the thickness and bearings of formations, a continuation of the Henderson series, immediately below the Ohio river at that place, then this lower coal must have increased in thickness above what it is in the Henderson shaft, or at the mouth of Panther creek, being, at the former place, only four feet six inches; at the latter, four feet two inches, provided its thickness, in the Deer creek borings, is correctly reported. The intermediate coal is thin—only some one and a half feet—and lies not far above the main coal, (eight feet.)

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*I had no nitro-prusside of sodium or other re-agent at that time, for determining the presence of sulphuret of alkali, but the quantity of sulphur present, as well as soda, indicate the probable presence of sulphuret of sodium.

## COAL MEASURES

### *Of Henderson, Daviess, Ohio, Butler, Edmonson, Grayson, Hancock, and Breckinridge, and part of Warren counties.*

The section of the Upper Coal Measures, described in the first chapter of the Report, gives an insight into a thousand feet of the Coal Measures of Henderson county. The same is shown on a large scale in the vertical diagram, No. 2. The remarks embodied in that part of the report, in regard to the equivalency of the Henderson coals, is all that can be said, *at present*, on that subject.

The following is the chemical analysis of coal No. 206, of the State collection, situated near low water of the Ohio river, at Henderson:

| | | |
|---|---|---|
| Total volatile matter, | | 45.5 |
| Coke, | | 54.5 |
| | | 100.0 |
| Moisture, | 6.0 | |
| Volatile combustible matter, | 39.5 | |
| Fixed carbon in coke, | 44.5 | |
| Ashes, (grey,) | 10.0 | |
| | 100.0 | |

In coking it forms small mammillary excrescences. Coke of fair quality.

As yet we have no analysis of the four and a half-foot coal, lying at a depth of from ninety-three to one hundred feet in the Henderson shaft. I subjoin, however, an analysis of a coal which will probably prove to be its equivalent:

| | | |
|---|---|---|
| Total volatile matter, | | 44.5 |
| Coke, | | 55.5 |
| | | 100.0 |
| Moisture, | 11.5 | |
| Volatile combustible matter, | 33.0 | |
| Fixed carbon in coke, | 47.0 | |
| Ashes, | 8.5 | |
| | 100.0 | |

The coal on Bluff creek, above Curdsville, ten feet below high water of Green river, at Cook's mine, is probably the southern extension of the same bed, rising in its southerly course up the valley of Green river. At this mine the coal measures four feet two inches.

At some localities there appears to be a thin seam of coal about twenty feet above this bed, but of no practical value so far as we have yet observed it.

The next coal in the descending order is a bed from two and a half to three and a half feet thick, which comes in eighty-four to ninety-eight feet below the last, lying in the Henderson shaft, one hundred and eighty-five feet below the Ohio river. This is perhaps the bed which, rising in a south-easterly direction, appears on the Horse fork of Panther creek, in Daviess county, three and a half miles a little south of east of Owensboro', on Mr. Sharp's farm, covered by shale containing fossil *Productus* and other shells, converted into iron pyrites. No analysis of this coal has yet been made.

To the next workable coal is one hundred and eighty-four to two hundred feet. This is perhaps the same bed which rises forty or fifty feet above the Ohio river, three or four miles below Owensboro', and known there under the name of the Bonharbor coal of Daviess county. This coal has the following composition at that mine:

| | | |
|---|---|---|
| Specific gravity, | 1.273 | |
| Total volatile matter, | | 48.3 |
| Coke, | | 51.7 |
| | | 100.0 |
| Moisture, | 7.0 | |
| Volatile combustible matter, | 41.3 | |
| Fixed carbon in coke, | 46.7 | |
| Ashes, (light grey,) | 5.0 | |
| | 100.0 | |

A few inches of the upper part of the Bonharbor coal is slaty, hard, and close-textured, having a structure approaching to Cannel coal. By analysis this part of the bed yielded,

| | | |
|---|---|---|
| Specific gravity, | 1.526 | |
| Total volatile matter, | | 38.0 |
| Coke, | | 62.0 |
| | | 100.0 |
| Moisture, | 4.5 | |
| Volatile combustible matter, | 33.5 | |
| Fixed carbon in coke, | 37.0 | |
| Ashes, | 25.0 | |
| | 100.0 | |

It does not swell much in coking; forms a coke of fibrous structure; crackles in burning. This is a very inferior part of the Bonharbor bed, and should be rejected, as it will clog the grate with ashes.

There is also about a foot or a foot and a half of this coal at the Bonharbor mines that is very pyritiferous, and should be rejected or only sold for burning lime or other such purposes; were this done the Bonharbor coal would bear a better reputation than it has at present.

About thirteen feet above this coal is a thin coal, a foot or eighteen inches thick, which was struck in sinking the air shaft at the Bonharbor mines; it was passed through in the Holloway borings at about the same distance above the main coal. One hundred to one hundred and five feet below the main Bonharbor coal succeeds, in the descending order, a coal varying from thirteen to eighteen inches in thickness, which is just below low water mark under the Coal Haven factory, and is five feet above low water above the head of French island, on the Indiana shore, two miles below Enterprise. It has the following composition:

| | | |
|---|---|---|
| Total volatile matter, | | 47.0 |
| Coke, | | 53.0 |
| | | 100.0 |
| Moisture, | 6.0 | |
| Volatile combustible matter, | 41.0 | |
| Fixed carbon in coke, | 46.5 | |
| Ashes, | 6.5 | |
| | 100.0 | |

Does not puff up much in coking; throws out small mammilliary excrescences; coke of fair quality.

The shales, both above and below this coal, contain considerable quantities of carbonate of iron. Interstratified in the shale, above the head of French island, is a band of dark bituminous, ferruginous, calcarious rock, rich in fossil remains, amongst which the *Spirifer faciger* and *Chonetes mesoloba* are conspicuous. The strata, at low water, below the Coal Haven factory, in Daviess county, occupy the same geological position; and it is probable that the coal in the bed of Green river, below the town of Livermore, in Ohio county, and the shales and iron stones in the bank at that landing, are of the same date. No coal is known below this for about three hundred feet, when a bed reported to be six and a half feet in the Holloway borings sets in under a mass of one hundred and seventy-seven feet of shale, and overlying a great thickness of sandstone. It is surmised that this may be the same coal which in Union county underlies the Wash creek shales, and overlies the Bethel Hill sandstones; but these are matters which can only be satisfactorily determained by the detailed geologico-topographical survey. If this supposition be correct then the French Island and Coal Haven coal would occupy nearly the same position as the coal associated with the Chapel Hill shales of Union county.

The materials forming the Coal Measures in the northern part of Daviess and Henderson counties, being for seven or eight hundred feet soft and unresisting, they have suffered greatly from denudation; this is the reason why few or no hills or rocky bluffs are found on the Ohio river, for a long distance, from near Puppy creek, in Daviess county, to Henderson, and even a long distance below that place. In fact, this part of Kentucky, for many miles south of the Ohio river, presents a continued succession of beautiful level and productive lands; based, for the most part, on a substratum of clay, and partaking, to a considerable extent, of the nature of the fine quaternary soil heretofore spoken of when treating of the Jackson Purchase. This soil is admirably adapted for the growth of maize and fine silky tobacco: specimens of this soil, from Daviess county, have been collected for chemical analysis, but it could not be placed in the hands of the chemical assistant before his report had to be completed. I would only here remark, at the present time, with regard to the soils in question, that their fertilizing properties are, for the most part, too severely taxed by a continued succession of exhausting crops, like corn and tobacco. To keep it in good heart it is necessary that there should not only be a rotation of crops, but they should be every four or five years renovated by a clover crop turned in entirely, or, if the land can ill be spared for a season, be ploughed under after one cut of clover-hay has been removed.

The same causes which operated to produce this fine soil have also rendered the study of its geology difficult and obscure, from the scarcity of good natural sections; the soft material having crumbled away, the bassetting edges of the strata are concealed from the scrutiny of the geologist by the extensive debris that has overspread this country. In the high ground forming the sources of the Horse fork of Panther creek there are several out-crops of coal, covered by a fossiliferous shale, and lying generally under the sub-soil. The bed is only from twenty to twenty-four inches, where I have had an opportunity of inspecting it, and cannot therefore be considered a profitable bed to work.

At Squire Dugan's coal has been struck in his well, forty to fifty feet under a mottled limestone, very much resembling in appearance the limestone of Daviess ridge, in McLean county. The most important bed of coal, hitherto observed in this neighborhood, in Daviess county, is in the forks of Panther creek, in a hill known as "Wolf Hill," on Mr. Brinning's farm. The out-crop is thirty to forty feet above the base of the hill, in the midst of soft shaly rocks both above and below it, and having a covering of about ninety feet of hill, mostly composed of grey shales, argillaceous and dark near the coal, and becoming lighter colored and more silicious towards the top, with yellow ferruginous streaks. At the entry the coal measures twenty-eight to thirty inches. Mr. Hunter informs me that, including the soft coal at the bottom, Dr. Stevens' measurement made it thirty-four inches near the entrance, and thirty-six inches one hundred and four feet in the drift, as the soft coal becomes harder in that distance, and the coal increases two inches in thickness. The bed runs nearly horizontally into the hill, with an undulating floor of fire-clay, which Mr. Hunter says flattens out fifty feet in the entry. This coal come out in good blocks, with a bright and clean surface.

Two chemical analyses have been made of this coal, (No. 189 of the State collection;) the first taken from the drift soon after it was entered; the second from the face of the present entry after driving it one hundred and four feet into the hill:

| | | |
|---|---|---|
| Specific gravity, | 1.228 | |
| | *1st.* | *2d.* |
| Total volatile matter, | 44.8 | 42.4 |
| Coke, | 55.2 | 57.6 |
| | 100.0 | 100.0 |

| | *1st.* | *2d.* |
|---|---|---|
| Moisture, | 12.0 | 12.0 |
| Volatile combustible matter, | 32.8 | 30.4 |
| Fixed carbon in coke, | 54.2 | 56.6 |
| Ashes, | 1.0 | 1.0 |
| | 100.0 | 100.0 |

It forms a tolerably compact coke, with metallic lustre, some portions of which have a tendency to assume a remarkably crystaline structure.

This is a bright pure coal, free from earthy matter, and richer in carbon than the average of the coals of the western coal field. It is one of the best coals for manufacturing purposes in this part of the basin. The only disadvantage it possesses is the considerable amount of imbibed moisture. There are a few thin laminæ of pyrites and hydrous aluminate of silica (*Pholerite,*) in some of the joints, but on the whole, it is freer from sulphuretted impurities than the majority of coals.

The exact position which the Wolf Hill coal occupies in the Coal Measures is, as yet, problematical, but it must be towards the middle of the series. In the same hill, twenty-seven feet above the main bed, is a black dirt, which no doubt marks the place of a thin overlying coal.

One and a half miles north-east of Wolf Hill a coal, said to be twenty-six inches in thickness, is seen in the bed of a branch on John Watkins' farm; also, on John Boon's farm. It is supposed to be the same as the main Wolf Hill coal. A coal of similar appearance, quality, and thickness occurs also in a ravine on the Smith Fuqua farm, three miles south of Wolf Hill, and two and half miles from Miller's mill, on the south branch of Panther creek. It is covered by seven and a half feet of shale. At a height of fifty to sixty feet above, a sandstone is seen in place, about twenty-five feet below the top of the ridge.

The wet and miry bottoms of South Panther, near Miller's mill, indicate the proximity of some considerable body of argillaceous shale in the neighborhood. Immediately under the mill on that creek seven feet of argillaceous shale are exposed, capped with ledges of sandstone, and resting on soft sandstones, visible in the bed of the creek.

Two miles above Livermore, in Ohio county, a coal four feet four inches in thickness lies in the bluffs of Green river, seventy feet above the river. This coal is equivalent to that in Everly's ridge, shown in section elsewhere in this report, and is covered, like it, with thick beds of sandstone.

The coal exposed in a hollow a little further up Green river, and about a quarter of a mile back from the river at the Woodward bank, which may be traced through Muhlenburg and Hopkins counties, but lies low in the former county, under the Cypress flats; the line of fracture passing probably near Judge Eaves' sulphur spring, and crossing Pond river somewhere near the Fish Trap ford.

Through the "Island District" there is a fine body of arable land, occupying knolls and gently rolling swells, elevated thirty to fifty feet above the flats. The soil is of the nature of the fine loams of the quaternary deposits of the Jackson Purchase, only rather more argillaceous, supporting a heavy growth of Beech, intermixed with Poplar and Hickory, with an undergrowth of Pawpaw, *Annona triloba*.

The "Thoroughfare," lying between Green river and Cypress creek, is heavily timbered with Gum, White Oak, &c. It would make fine meadows, and would yield fine crops of corn, but is not in cultivation from being subject to overflow.

An extensive, low, narrow gravel bank circumscribes the flats of Cypress. Its course, from the lower part of that stream, runs through McLean and Muhlenburg counties, keeping from one to three miles distant from Pond river, until it crosses that stream at Millport, running thence from one to three miles, on its west side, until it again reaches Pond river at Ashbysburg. This gravel bank has, undoubtedly, been transported by currents established in the ocean at the time of the above mentioned disturbance, which rent assunder the Coal Measures in this vicinity, bringing the millstone grit and sub-carboniferous limestone to the surface.

At Davies' ridge sandstone and limestone, probably of the same date as those at South Carrollton, are tilted to the south-east, at an angle of 10° to 15°, by the uplift in question.

This Davies' ridge sandstone, which is fifteen to twenty feet thick, affords an excellent freestone for building purposes, and lies conveniently for quarrying. The limestone is here two to three feet thick, underlaid by yellow shales, including argillaceous iron ore; and the same limestone crops out in a field opposite Judge Eaves' house. In the hollow below his house, is the sulphur spring previously mentioned. Tested at the fountain head the "Social Hill Mineral Water" was found to contain, as its principal constituents:

Free sulphuretted hydrogen,
Bi-carbonate of soda and potash?
Sulphate of soda,

A little chloride of sodium, and probably
Sulphuret of sodium?*

After being boiled down it effervesces freely with acids, and turns reddened litmus paper blue. It contains less lime than is usually found in ordinary well and spring water. It is, no doubt, a valuable water for the cure of diseases of the skin, tinea capitis, psora, chronic pectoral affections, as an anti-lithic, and a gentle laxative, and therefore beneficial in improving the general health in many chronic affections.

On the north side of the above fault, towards the mouth of Cypress creek, dark shales and ironstones, including a bed of coal two and a half feet in thickness, basset in the banks of that stream. Fifteen feet of black shale, overlaid by ten feet of light grey shale, with clay ironstone, appear on the right bank of Green river, at the Livermore landing; under the black shale there is said to be an eighteen-inch coal under the bed of the river. These shales, ironstones, and coal are supposed to be of the same date as the shales, ironstones, and coal seen near low water of the Ohio river, at Coal Haven, and near the head of French Island, but this is, as yet, uncertain.

At Mr. Samuel's, in the north-east part of McLean county, on Deer creek, about six miles above its mouth, three coals occur in a distance of eighty feet—the upper, two and a half feet, the lower, a thick coal struck at the bottom of the boring, reported five feet or more. But if this coal series should prove to be, as seems likely, from the thickness and bearings of formations, a continuation of the Henderson series, immediately below the Ohio river at that place, then this lower coal must have increased in thickness above what it is in the Henderson shaft, or at the mouth of Panther creek, being, at the former place, only four feet six inches; at the latter, four feet two inches, provided its thickness, in the Deer creek borings, is correctly reported. The intermediate coal is thin—only some one and a half feet—and lies not far above the main coal, (eight feet.)

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*I had no nitro-prusside of sodium or other re-agent at that time, for determining the presence of sulphuret of alkali, but the quantity of sulphur present, as well as soda, indicate the probable presence of sulphuret of sodium.

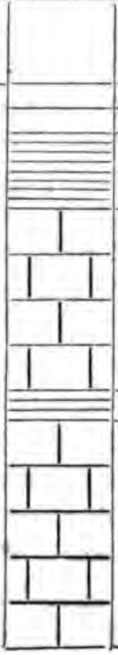
from the surface, and a thin coal of one to one and a half feet occurs at a spring one fourth of a mile east of the Four Mile house, on the Morgantown road.

A minute topographical survey made in Ohio county, from Porter's landing by these various localities, would not only determine the true geological position of those numerous out-crops of coal above mentioned, but unfold other important beds of coal, which there is reason to suppose both overlie and underlie the Austin coal.

Between Harrison's and Culbertson's a sample of soil was collected for analysis, peculiar for the luxuriant crops of herd-grass which it bears; the soil is also well adapted for corn, but, after a few years of successive crops of this grain, it is unproductive until sodded; subsoiling and clover fallows subsequently turned in, would greatly improve such land.

The approximate geological section obtained of the Green river bluff's, to the height of nearly three hundred feet, is instructive, and throws more light on the elements of the Coal Measures of Ohio county than any locality yet visited in that county.

SECTION OF TAYLOR'S COAL MINE, AT PORTER'S LANDING.

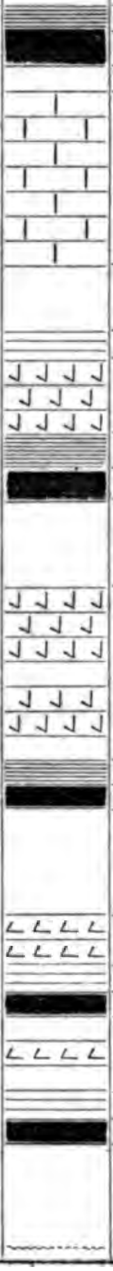


| Feet. | Inches. | Feet. | Inches. | |
|---|---|---|---|---|
| 300 | | | | Soil. |
| | | | | Subsoil. |
| 286 | | 16 | | Shale? concealed in slope. |
| | | 32 | | Upper bench of sandstone, in thick beds. |
| 250 | | 4 | | Shale? between benches of sandstone |
| | | 35 | | Lower bench of sandstone, in thick beds. |

The only bed at present worked is the upper bed under heavy sandstone, at an elevation of two hundred and five feet above Green river.—Mr. Stephen Taylor works this bed to supply steamboats plying on Green river.

Near the top of a high ridge, one quarter of a mile west of this section, heavy

SECTION OF TAYLOR'S COAL MINE—Continued.



| | Feet. | Inches. | Feet. | Inches. | |
|---|---|---|---|---|---|
| | | | 1 | 6 | Black shale. |
| | 205 | | 4 | 6 | Coal 4 feet 6 to 5 feet 1 inch. |
| | | | | | Fire clay. |
| | 184 | | 21 | | Sandstone. |
| | | | | | Space concealed. |
| | | | | | Silicious shales. |
| | | | | | Dark shale, with segregations of carbonate of iron. |
| | | | | | Black shale. |
| | 144 | | | | Coal. |
| | | | | | Space concealed. |
| | 110 | | | | Shale, with silicious iron ore. |
| | | | | | Black shale. |
| | | | | | Coal. |
| | | | | | Space concealed. |
| | | | | | Conglomerate limestone or pudding-stone. |
| | 65 | | | | Shale. |
| | | | | | Coal. |
| | | | | | Limestone. |
| | 53 | | | | Shale. |
| | 47 | | | | Coal—thickness not known. |
| | | | | | Slope to low water, with rocks concealed. |
| L. W. | 0 | | | | Green river. |

ledges of sandstone are in place, inclosing a kind of ferruginous conglomerate and some masses of limestone; and one mile northeast, in a ravine, ledges of conglomerate limestone crop out seventy feet above high water, covered by shale, with silicious iron ore. Coal appears here in natural out-crop in the bank of a branch, a few feet below the above limestone.

In the east part of Ohio county, on the waters of Indian Camp creek, I had occasion to examine one of the most suspicious waters of this part of Kentucky, supposed by many to have caused the death of many cattle, with all the symptoms of milk-sickness or trembles. Sulphuretted hydrogen, passed to saturation through this water, gave no indication of the presence of arsenic, lead, antimony, or any of these poisonous metals; but I found the water possessing strong astringent properties from the presence of sulphate of alumina and sulphate of the protoxide of iron, confirming the views heretofore entertained in regard to such waters, treated of at length elsewhere in this report.

This water issues from near the level of a thin coal lying some twenty-five feet beneath the general surface of the farming lands of this part of Ohio county, covered by two to three feet of black shale. On the divide between Indian Camp creek and Welch's creek are heavy ledges of sandstone, and on the south-east slope below some hydrated oxyde of iron; this surface ore is, however, too silicious to be a good and profitable working ore.

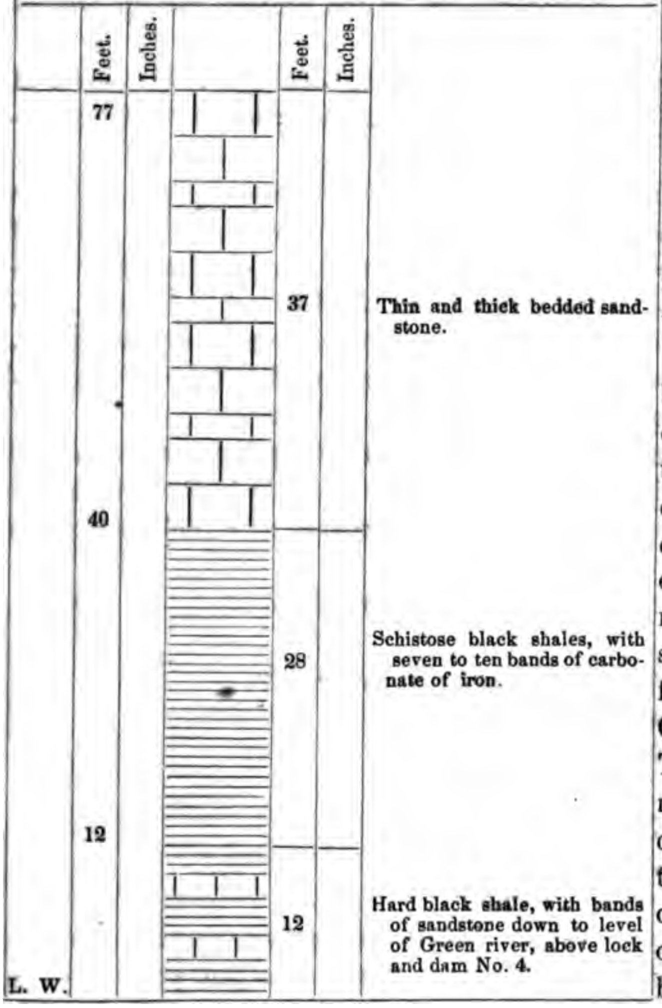
Naut's coal, two miles south of Morgantown, lies on the waters of Sandy creek, from ten to fifteen feet below the surface of the ground bordering on this branch. It is worked at present only by stripping. It is between three and four feet in thickness, and is in good repute, not only with the blacksmiths of the neighborhood, but with those of Simpson county. It is probably one of the lower coals of the basin, rising to the surface towards the south-eastern confines of the western coal field.

Russey's coal, on Big Muddy creek, is supposed to be the same bed.

No coal was struck in the distance of fifty-two feet, in sinking the public well at Morgantown; the material passed through was chiefly sandstone, some of which was hard and quartzose; impure limestone is also reported in this excavation.

In the bank of Green river, at Woodbury, just below the confluence of the two principal forks of this river, we obtained the following section:

SECTION AT THE FORKS OF GREEN AND BARREN RIVERS.


Feet.
Inches.
Feet.
Inches.
77
40
12
L. W.
37
Thin and thick bedded sandstone.
28
Schistose black shales, with seven to ten bands of carbonate of iron.
12
Hard black shale, with bands of sandstone down to level of Green river, above lock and dam No. 4.

There is, probably, a workable bed of coal no great distance beneath the bottom of this section, occupying the place of the main Nolin coal, to be noticed hereafter.

Three miles above the mouth of Barren river the first ledges of sub-carboniferous limestone emerge, as yet noticed, in a south-east course from the forks of Green river.—This is in the north-west corner of Warren county, on the waters of Clay Lick creek, at Neighbors' farm.

There is said to be a two-foot coal in Warren county, which shows its out-crop on Lost creek, and was also seen on Indian creek before the dam was constructed below the mouth of Upper Ivy creek, in the neighborhood of Young's.

Limestone is in force on Swan creek, and can be found low down in most of the exposed sections on Ray's branch, the tops of the ridges being capped with sandstones of the millstone grit series. At some localities in this vicinity the limestone has frequently a conglomerate or pudding-stone structure. Above this limestone, on the waters of Clay lick, seven miles above the mouth of Barren river, in Warren county, some tolerably good iron ore, of the limonite variety, was observed.

The blacksmiths of Bowlinggreen obtain some coal on the waters of Little Reedy creek, but I have not yet had an opportunity of examining it.

The ridges in the south-western part of Edmonson county, which give rise to the waters of Little Beaver-dam creek, are composed of sandstone of the millstone grit. Passing to the east, an abrupt descent of one hundred and eighty to two hundred feet leads into a beautiful valley, based on the limestone of the sub-carboniferous group, watered by Alexander's branch. On the declivity the oolitic beds of the sub-carboniferous group are in place.

In the immediate vicinity of the Chamelion Springs the Pentremital limestone makes its appearance a few feet above the level of the mineral spring, the surrounding hills being capped with sandstone of the millstone grit.

The principal constituents of the waters of the Chamelion Springs, are,

Small quantity of free sulphuretted hydrogen;
Free carbonic acid gas;
Sulphate of soda?
Chloride of sodium;
Bi-carbonate of lime;
Bi-carbonate of magnesia, a trace;
Sulphate of magnesia, a trace;

It is neutral to test paper. It does not appear to contain sulphuret of alkali, since nitro-prusside of soda produces no perceptible effect on the unconcentrated water, and when boiled down until all the free carbonic acid has escaped, and the whole of the carbonate of lime and magnesia is deposited and separated by filtration, no effervesence was observed by the addition of nitric acid.

Where the water runs off over leaves and other vegetation three different sediments subside—one is black, one purple, and the other white. The white sulphur water, near by, seems to contain less sulphates but more chloride than the other spring, and deposits only a small light-colored sediment.

I also tested, partially, a sample of the chalybeate water owned by Mr. Swinney, one and a half miles from the Chamelion Springs, brought to me for examination. Its principal constituents are,

Free carbonic acid gas;

Bi-carbonate of the protoxide of iron;

Bi-carbonate of lime and magnesia;

Small quantities of chlorides, probably chiefly chloride of sodium.

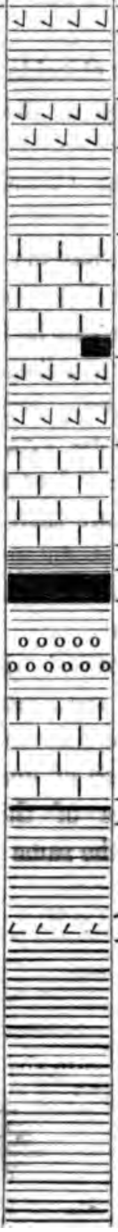
It has a slight oily looking scum, which collects on the surface, due to a film of petroleum.

There is a feeble chalybeate water also on the Chamelion Spring property.

Between this locality and Brownsville are alternations of sandstone and limestone, with a conglomerate resting immediately on limestone, within a mile of Brownsville. The conglomerate can be traced on the north side of Green river, between two and three miles, to a school house on the top of the hill, on the Litchfield road. From this point table land, resting on sandstones of the millstone grit, extends for eight miles in a northerly direction, when there is a descent to the valley of Nolin creek, of over two hundred feet; more than three-fourths of this is limestone, with some alternations of sandstone and chert. The bed of Nolin creek, near the northern confines of Edmonson county, is Pentremital and Archimedes limestone.

Several beds of valuable iron ore are interstratified with the ferruginous shales in the sixty or seventy feet of the upper part of the section of the Nolin ridges. It is from this source that the Nolin Furnace was to be supplied with iron ore, but the death of one of the owners of the property prevented the continuance of the enterprise. There is also a valuable bed of workable coal in the same hills.

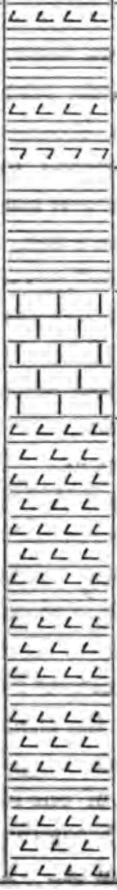
### APPROXIMATE SECTION OF THE GEOLOGICAL FORMATIONS OF THE NORTHERN PART OF EDMONSON COUNTY, ON WATERS OF NOLIN CREEK.



| Feet. | Inches. | Feet. | Inches. | |
|---|---|---|---|---|
| 250 | | | 6 | Top-hill ore. |
| | | 8 | | Shale. |
| | | 2 | | Ferruginous shale, with middle bed of iron ore. |
| | | 10 | | |
| 220 | | 20 | | Upper bench of sandstone, locally underlaid by coal? |
| | | ? | | |
| | | 10 | | Dark shale, with carbonate of iron, and probable place of fossiliferous iron ore? lying further north. |
| 200 | | | | |
| | | 18 | | Sandstone. |
| | | 1 | | Grey metal. |
| 180 | | 4 | | Main Nolin coal 4 to 5½ or 6 ft |
| | | | | Shale, with iron stones. |
| 170 | | 20 | | |
| | | | | Schistose sandstone, (local.) |
| 160 | | | 4 | 4 to 6 inch coal. |
| | | 11 | | |
| 150 | | | | Upper grey limestone. |
| | | 50 | | Space chiefly filled with marly shales, with perhaps some thin intercalations of limestone. |
| 100 | | | | |

The black shale, with carbonate of iron, lying between two hundred and two hundred and twenty feet above Nolin creek, is probably the equivalent of the shale, including ore, noticed as occurring on Green river, below its confluence with Barren river. It occupies, moreover, nearly the same geological horizon, with reference to the distance above the upper grey limestone, that the fossiliferous argillaceous iron ore does, situated about a mile to the north-west of the section here given. At that locality considerable carbonaceous matter is disseminated, and the ore bed is overlaid by a schis-

APPROXIMATE SECTION IN EDMONSON CO.—Continued.



| Feet. | Inches. | Feet. | Inches. | |
|---|---|---|---|---|
| | | 16 | | Lower buff and yellow limestone. |
| 90 | | | | Marly shales. |
| | | 5 | | Limestone |
| 85 | | | | Band of cellular chert. |
| 70 | | 15 | | Space, with marly shale? |
| 55 | | 15 | | Shaly sandstone. |
| | | 55 | | Limestones, with partings of marly shales. |
| 0 | | | | Archimedes and Pentremital limestone in the bed of Daviess' branch of Nolin creek. |

tose sandstone very similar in appearance to that covering a coal on Daviess' branch.

These observations have led to the inference that a bed of coal may possibly be found in some portions of Edmonson county under this upper bench of sandstone, when the country comes to be surveyed in detail.

The middle ore bed comes in about twenty-five or thirty feet above the fossiliferous iron ore and shale, which, with some disseminated shaly matter, is two feet thick; and another six-inch bed of ore skims the tops of the highest points of the ridges, some ten to fifteen feet higher in the section.

Only an approximate analysis has been made of one of these ores, which is essentially a carbonate yielding 54 per cent. of protoxide of iron, equal to 41.1 per cent. of metallic iron.

A remarkable feature in the geology of Edmonson county is witnessed at the mouth of Dismal creek, between two and three miles east of north of the above section. One hundred and fifty-five feet of pebbly sandstone and conglomerate appears here in vertical escarpment, (see plate No. 6,) resting on Archimedes limestone, similar to the rocks at the base of the section just presented, and occupying, therefore, the place of the alternations of limestone, sandstone, chert, marly shales, and coal of that section, We are led to infer, from this local modification of the order of superposition, either that the horizontal continuity of the strata of deposition was interrupted at the mouth of Dismal creek, and some very local cause operated to produce an entirely different sediment from that accumulating to the south, or, what is perhaps more probable, powerful local currents, sweeping over this point, first carried away some one hundred and fifty feet of the original material forming the ocean's bed, the denuded space being subsequently filled in with sand and gravel, when the force of the rushing waters was in some measure retarded. The very local position of the conglomerate, at the base of our Coal Measures, and its prevalence in the vicinity of the principal water courses, in valleys along which we might expect ancient currents to have been directed, lends probability to this latter conclusion. It is to similar causes that I am disposed to attribute the fact that the lower coal beds are often irregular in thickness, or entirely cut off, in the immediate vicinity of the conglomerate. Such strong currents were undoubtedly established by extraordinary upheavals, and changes taking place at that period in the bed of the ocean. These disturbances and denuding causes also explain those abrupt attenuations sometimes noticed near the conglomerate, particularly where the strata are thrown into anticlinal folds. At several localities in this neighborhood coal naptha, or petroleum, oozes from near the place of one of the coals of this part of Edmonson county, which, after becoming inspissated, forms a kind of consistent mineral pitch or coal-tar. It yielded, by approximate analysis, as follows:

| | | |
|---|---|---|
| Specific gravity, - - - - - - - - - - | 1.362 | |
| Total volatile matter, - - - - - - - - - - - | | 59.7 |
| Coke, - - - - - - - - - - - - - - | | 40.3 |
| | | 100.0 |
| Moisture, - - - - - - - - - - - | 0.0 | |
| Volatile combustible matter, - - - - - - - | 59.7 | |
| Fixed carbon, - - - - - - - - - - | 14.3 | |
| Ashes, - - - - - - - - - - - | 26.0 | |
| | 100.0 | |

Two coals taken from different localities whence this mineral pitch occurs yielded,

| | | |
|---|---|---|
| Specific gravity, | 1.291 | |
| | 1st. | 2d. |
| Total volatile matter, | 40.0 | 45.2 |
| Coke, (unchanged,) | 60.0 | 54.8 |
| | 100.0 | 100.0 |

| | 1st. | 2d. |
|---|---|---|
| Moisture, | 3.0 | 4.7 |
| Volatile combustible matter, | 37.0 | 36.5 |
| Fixed carbon, | 40.0 | 53.8 |
| Ashes, | 20.0 | 5.0 |
| | 100.0 | 100.0 |

On the south side of the ridge dividing Nolin from Daviess' branch coal-tar oozes from under and out of a five and a half foot (5½) coal, exposed in a good natural section, forty-five feet above a dark grey limestone, and sixty feet under a bench of sandstone; also on the north side of the same ridge, from under ledges of sandstone. Here no coal is visible, but it is probably the place of another bed of coal. Twenty feet above a cliff of conglomerate, and probably on the same geological horizon as the last mentioned locality, on Mr. Morris' property, in the western part of Edmonson county, near the head of Buffalo creek, the same material percolates from the earth.

From the frequent occurrence of this material in Edmonson county, I am disposed to think that coal, suited to the production of burning and lubricating oils, and Paraffine or paranapthaline, may be found by a minute survey. The crude material, when freed from adhering earthy impurities, is used by the inhabitants for greasing wagons, pitching boats, and other such purposes, since it can be collected both in the liquid and solid form.

The lowest bed of "mountain ore," lies forty to fifty feet above the grey limestone measures, with disseminated shale, three feet five inches, to four feet six inches. It is rather more earthy than the middle bed, twenty to thirty feet higher in the hills. This bed, with disseminated shale, is some two feet thick, and the top hill ore, ten to fifteen feet higher in the section, is only four to six inches thick. The lowest of these beds lies fifteen feet above a bench of sandstone, but, until accurate levels are carried over the county, by the detailed survey, it is difficult to say whether this is the upper or lower bench of sandstone; if above the upper bench, then there is one more ore bed than is represented in the provisional section heretofore given.

Judging from the strike-line and dip of the formations on Nolin and Buffalo creeks there are doubtless out-crops of both coal and iron ore to be found on Bear creek, but these I have not had an opportunity of investigating. The best soil of the table land of Edmonson county supports a growth of white and black oak, hickory, poplar, and dogwood. The second rate table land soil is indicated by a growth of "spotted" red oak, *Quercus coccinea?* These table land coal measure soils, may be considered the prevalent soil of Edmonson county, being much more extensive than the bottom lands, which derive, locally, a portion of their ingredients from the intercalated beds of subcarboniferous limestone that crop out at the base of the hills. The Edmonson county soils are well adapted to the growth of flax. They also produce good crops of small grain and fine tobacco; they are not so well suited for corn crops, which soon exhaust them.

Sandstone, suitable for hearthstones, crops out a little above Daviess' branch, lying in beds from six inches to two feet, and dipping from 1° to 2° south, 80° east, which assumes, however, a much higher angle of some 10° further down the branch, where there is a local wave of the strata.

On the waters of Buffalo and Calloway creeks, beds of hydrated brown and yellow oxide of iron occur, apparently of good quality, but, as these have not yet been fairly opened, I am unable, at present, to report particularly in regard to them.

High cliffs of conglomerate, 150 to 170 feet in thickness, resting on limestone, similar to those on Dismal creek, occur on the head waters of Buffalo, at the base of which issues the "Big Spring," giving origin to that creek; and flowing off over buff beds of Archimedes and oolitic limestone.

Thirty-five feet under this comes in a bed of black shale and fire-clay which lies in the bed of the creek. The black shale has been mistaken for coal. It is possible that between the shale and fire-clay there may be a bed of coal of a few inches in thickness, equivalent to some of the thin coal seams found in the vicinity of Stevensport, in Breckinridge county; but it is improbable that any bed of coal of practical value will be discovered as low down in these hills.

The conglomerate can be traced, in a direction west of south, to the descent from the table land down to Green river.

On the south side of Green river the platform of limestone, forming the descent into the Mammoth cave, is two hundred and thirty-two feet above Green river.

The entrance to the cave, being thirty-eight feet lower than this bed of limestone, is one hundred and ninety-four feet above Green river. In the above two hundred and thirty-two feet, there are several heavy masses of sandstone, viz: at one hundred and twenty-five, one hundred and forty-five, one hundred and fifty, one hundred and sixty, and two hundred and fifteen feet, but it is probable that most of these have tumbled from higher positions in the hill, as no alternations of sandstone have been observed at these levels in the cave. From an elevation of from two hundred and forty to two hundred and fifty feet, the prevalent rock is sandstone without pebbles, which can be seen extending up to three hundred and twelve feet to the foundation of the Cave hotel. The united thickness of the limestone beds on this part of Green river, is about two hundred and thirty feet, capped with eighty feet of sandstone. About midway of the section on this part of Green river, are limestones of an obscure oolitic structure, but no strue oolite was observed. Many of these limestones are of such a composition as to be acted on freely by the elements of the atmosphere, which, in the form of nitric acid, combine with the earthy and alkaline bases of calcareous rock, and give rise to the formation of nitrates, with the liberation of carbonic acid; hence the disintegrated rubbish of the caves yields nitrate of potash after being treated with the ley from ashes and subsequent evaporation of the saline lixivium. The wonderfully cavernous character of the sub-carboniferous limestones of the Green river valley, and, indeed, of these particular members of the sub-carboniferous group, throughout a great part of its range in Kentucky and Indiana, is due, in a great measure, to this cause, together with the solvent and eroding effects of water charged with carbonic acid. The "Rock-Houses" frequently encountered both in this formation and in the limestones of Silurian date, are produced by similar causes; the more easily disintegrating beds gradually crumbling away, while the more durable remain in overhanging ledges.

By the oxidation of other elements, sulphates of oxide of iron and alkalies result, which, by double decomposition, with carbonate of lime, give rise to the formation of gypsum, which appears in the form of rosettes, festoons and various other imitative forms on the walls and ceiling of the caves. Crystallizations of sulphate of soda, and sulphate of magnesia are not uncommon, both in some of the caves and in sheltered situations under shelving rocks.

A few fossil brachiossæ and polypiferæ occur in the limestone of this part of Green river, but they are by no means abundant.

These cavernous limestones of the sub-carboniferous group overlaid by sandstone, which is occasionally pebbly, extend to the line of Barren and into Hart counties.

In Grayson county a tongue of the Coal Measures stretches away to the east, forming an irregular offset from the general contour of the western coal basin, as it sweeps round from Green river, in a general northerly course, towards the Ohio river, extending even on to the waters of Roundstone creek, in the north-western part of Hart county.

The Grayson Springs issue from fissures, in the Archimedes and Pentremital limestones. In a level area of about one and a half acres, before the grass was sown, Mr. Clarkson says he counted one hundred and twenty-six springs. An amphitheatre of hills about eighty feet in height, surrounds this area on the south-west, south and south-east, with a beautiful grassy slope descending towards the various outbursts of mineral water. These are known by different names, the most important of which I tested with various chemical re-agents at the fountain head.

The "Centre Spring" had a temperature of 62° F., the air being 75° F. at the same time. I found it to contain:

Free sulphuretted hydrogen;
Free carbonic acid;
Bi-carbonate of lime;
Bi-carbonate of magnesia;
Chloride of magnesium;
Chloride of (sodium?)
Sulphate of magnesia; (epsom salts)
Sulphate of (soda?)

Nitro-prusside of sodium gave only a faint trace of sulphuret of alkali.

The "Macatine Spring" contains the same ingredients, but the chlorides are more abundant than in the "Centre Spring." The sediment on the sandstone rock with which this spring is walled up, is of a deep pink purple.

The "Moreman Spring" has about the same quantity of chlorides as the Centre Spring, but the free sulphuretted hydrogen and carbonic acid are more abundant and escape more freely.

The "Stump Spring" is one of the strongest of the springs, both in sulphuretted hydrogen, sulphates and chlorides.

It has been the impression that these mineral waters contained protocarbonate of iron. No indication of this metal, either in the state of protoxide, or peroxide, could be detected in the unconcentrated waters, either by hydro-sulphuret of ammonium, ferrocyanide of potassium, gallic acid, nutgalls, or ammonia. Indeed iron and sulphuretted hydrogen are incompatable, except in an acid solution, and even in this case sulphur is rapidly precipitated if the iron exists in the state of sesquioxide during its reduction to protoxide. The sediment in the Moreman and Stump Springs is white. This white sediment, when treated with nitric acid, gave a copious precipitate, in neutral solution, with oxalate of ammonia, a whitish precipitate with acetate of lead, and a white precipitate with nitrate of baryta. It is probable that it is originally a sulphuret of calcium, which, after oxidation or treatment with nitric acid, becomes sulphate of lime. The solution of this sediment also gave evidence of the presence of magnesia by the crystalline precipitate produced by the addition of phosphate of soda and ammonia.

The medical properties of these waters are diaphoretic, aperient, and anti-scorbutic. To pronounce on their effects on the glandular system, which depends principally on the presence of iodine and bromine, it would be necessary to evaporate several gallons of the water nearly to dryness, and remove the earthy salts with pure carbonate of potash and alcohol, before applying the appropriate re-agents to determine the presence of these elements. This is a tedious and delicate operation, which can be accomplished satisfactorily only in a laboratory, and with a plentiful supply of the water at hand.

The peculiar qualities of these mineral waters; the beautiful location of the springs; the taste with which the grounds are laid off, together with the extensive and comfortable arrangements of the establishment, and the accommodating disposition of Messrs. Clarkson & Herndon, proprietors, render the Grayson Springs a place of great attraction to invalids in search of health, as well as those desirous of seeking amusement and recreation in an agreeable summer retreat.

The Encrinital beds associated with the Archimedes limestone, under the Catholic chapel, are rich in remains of crinoidea, one of which is figured and described by Professor L. Yandell in the July number of Silliman's Journal, page 136, under the name of *Actocrinus Shumardi.*

On the waters of Gilden's run, a branch of Little Clifty, on land owned by Robert Good, there is a mineral spring containing the same ingredients as the Grayson Springs, and close by is a chalybeate water, containing, besides proto-carbonate of iron, some sulphates, but no free sulphuretted hydrogen.

The Reedy Hills, in the south-west part of the county, dividing the waters of Bear creek and Caney creek, are, propably, the highest ridges in this county. They are composed chiefly of sandstone, with marly shales and limestone at their base, on the east side, known more particularly as the "Caney Ridge." These marly shales have been a great resort of buffalo in early times, and the cattle and deer, in the first settlement of the country, licked enormous holes into the bank at various places—no doubt owing to the presence of certain saline matter in these deposits. No very good exposures have yet come under my observation in these ridges, but, so far as I have seen, there is a great analogy in their formation and those hitherto described on the waters of Nolin creek and Daviess branch, leading me to suspect the occurrence of equivalent coal beds, and perhaps ore also, as ochreous shales were noticed in some of the ravines; but whether the coal and ore are of workable thickness, and of good quality, remains to be determined. Those out-crops of coal which I have as yet seen on the waters of Caney, are only from eighteen to twenty-two inches thick; one of these was a very hard, black, slaty coal, eighteen inches thick, somewhat similar in appearance to the Breckinridge coal.

The upland of this part of Grayson is better adapted for grazing farms than for raising corn, which succeeds much better in the more calcareous soil overlying the sub-carboniferous limestone and marly shales that crop out in the low grounds. Wheat, however, grows well on the new ground. On Mr. Hay's upland farm wheat weighing sixty-six pounds to the bushel was raised.

Large masses of hydrated oxyde of iron were observed on a hill on the waters of Clifty, in Grayson county, on the property of Isaac Craig. A good deal of this surface ore, where it lies in connection with sandstone towards the top of the hill, is somewhat silicious, but, as the Archimedes limestone comes out a short distance below, in the same hill, there is reason to believe that the ore will improve when the banks are fairly opened, and may very likely be traced into fissures of the underlying limestone, since surface ore is visible over one hundred to one hundred and fifty acres of ground, with a uniform bearing; at all events this locality is well worthy the attention of those wishing to embark in the iron business.

The falls of Rough present a very interesting exposure of highly fossiliferous Archimedes and Encrinital beds, affording also a great variety of well preserved corals, allied to the genera *Gorgonia*, *Retapora*, *Fenestella*, *&c.*, overlaid by thin-bedded sandstone, thus:

| | *Feet.* | *Inches.* |
|---|---|---|
| Brown, yellowish, grey, thin-bedded, schistose sandstone, - | 4 | 6 |
| Compact, light-brown and greenish-grey Archimedes limestone, and other fossils, - - - - - - - - - - | 2 | 6 |
| Dark shales, with thin layers of Spirifer and Archimedes limestone, - - - - - - - - - - - - - | 3 | |
| Compact, rough-surfaced, brownish-grey Spirifer limestone, containing fish teeth, and a lyra-shaped reticulated coral, 9 to | | 10 |
| Dark shale, - - - - - - - - - - - - | 4 | 6 |
| Dark grey earthy limestone, alternating with thin layers of dark shale, full of reticulated corals, Encrinites, Archimedes, and Productus, - - - - - - - - - - - - | 4 | |
| Dark light-grey limestone, containing Encrinites, Archimedes, and other corals, extending to low water of Rough creek, - | 1 | |
| | 20 | 4 |

The beds between two and five feet above low water are the richest in Encrinites; Spirifers and other brachiopodæ are most abundant in the layers between nine and ten feet above low water, associated with *Agassizocrinus conicus*, and teeth of sauroid fishes.

One and a half miles south-east of the falls of Rough, a two-foot coal occurs high in the hills, on the property of Mr. McClairen, about two hundred and sixty feet above Rough creek, thus—the numbers representing the height at which the rocks were found cropping out in the hills above Rough creek:

| *Feet.* | |
|---|---|
| 348. | Summit level above the coal bank. |
| 280. | Sandstone, three feet thick. |
| 274. | Dark schistose shale, three feet thick. |
| 271. | Black sheety shale, two feet thick. |
| 269. | Coal, two feet thick, dipping N. 50° W. |
| 267. | Fire-clay, two feet seven inches. |
| 230. | Green and grey marly shales, underlaid by upper buff limestone. |
| 201. | White limestone. |
| 176. | Lower buff limestone. |
| 111. | White limestone. |
| 71. | Oolitic limestone. |
| 15. | White limestone in bed of Pleasant run. |
| 0. | Archimedes and Encrinital limestones, as in previous section. |

At Smith's spring a coal lies some fifteen feet higher than at McClairen's, with solid ledges of sandstone five feet above it. It is probable that both coals occupy the same geological position.

Several out-crops of thin coal occur on the headwaters of Rock lick creek and Panther creek, from six to eighteen inches thick; also, on Tar creek. On the latter stream there is also an oozing of coal-tar, which will, according to Mr. Ryan, sometimes yield nearly a barrel in twenty-four hours. It hardens by exposure into a tough, pitchy substance like that heretofore described as occurring in Edmonson county, on the waters of Nolin. The same substance percolates from the lower part of the sandstone cliff at the Tar Spring, in Breckinridge county, and several feet of the equivalent sandstone further down the railroad is saturated with it. At the base of this cliff a milky looking mineral water issues, containing

Bi-carbonate of lime and magnesia;
Sulphates of (soda, magnesia, and lime?)
Chlorides of sodium and magnesium, in small quantity.

The celebrated Breckinridge coal mine lies from three to four miles west of south from these Tar Springs, in the edge of Hancock and Breckinridge counties, and between eight and nine miles from Cloverport, on the Ohio river. The height of the ridges in the neighborhood of these mines are from four hundred and twenty-five to four hundred and sixty feet; the Breckinridge coal lying about ninety-five feet under the summits of the main ridges. The dip is west from three or four inches to one hundred feet, or from thirteen to twenty-one feet in a mile. The coal varies in thickness from three feet six inches to twenty-two inches, and runs down, I understand, in some places as low as sixteen inches. At the face of the coal, in rooms leading from entry No. 8, where I had an opportunity of measuring it, I found it to be from thirty-one to thirty-two inches. The roof is a brown sandstone, with coaly and ferruginous matter irregularly disseminated. Locally a few inches of shale intervene between the coal and sandstone; the floor is fire-clay, with a thin band of ironstone running in it three or four inches below the bottom of the coal.

The coal has a wonderful degree of compactness and tenacity, so that it is difficult, even with a ponderous hammer, to effect a cross fracture; though it splits with tolerable facility in the direction of the lamination. The splinters flying from the fracture are exceedingly sharp, so that they cut the flesh wherever they strike fair. These properties enable it to stand handling and atmospheric agencies with as little loss as any coal that has come under my observation.

Numerous remains of fossil Lepidodendron may be observed on the surface of the horizontal partings, which are often coated with thin laminæ of iron pyrites. So frequent is the occurrence of the compressed remains of leaves and limbs of these arborescent Lycopodiaceæ in the very substance of the coal itself, that but little doubt remains in my mind that the peculiar chemical properties of this coal, and its consequent adaptation to the production of certain oils, benzole, and coal wax, &c., are due to its having been chiefly derived from forests of Lepidodendrons and resinous trees.

It has been supposed that a bed of bituminous coal, four to five feet in thickness, lies some one hundred feet below the Breckinridge coal, equivalent to the main Hawesville bed. Of this I have, at present, no evidence. Until the detailed geologico-topographical survey has been carried over this part of the State, I could not decide positively on this subject; but my impression is, so far as I have yet explored the country, that the Breckinridge coal will be found to occupy a geological position inferior to the Hawesville, or it may possibly be its equivalent; if inferior, then it seems to be represented, on the Ohio river sections, by one of those imperfect coal seams ("coal dust") lying there, from sixty to one hundred feet below the main Hawesville coal. I have been led to this conclusion from approximate measurements made from certain limestones to these different coals. The provisional section on diagram No. 4 gives my present views in regard to the order of superposition of the different strata and associate coals in Breckinridge and Hancock counties, which I submit as a temporary suggestion for further elucidation of these deposits, with this remark, that there is one space in the section, as yet problematical, both as to thickness and lithological character, i. e., the space above the Tar Spring sandstone, and under the marly shales below the slide at the Breckinridge mines. That space, doubtless, contains a coal, but in all probability not of workable thickness—as I know of no instance of the existence of a workable coal below the above mentioned shales and overlying limestone which are in place in the cut of the railroad between the Slide and the Scale House. The Breckinridge coal will, probably, prove to be the lowest *workable* coal on the eastern side of the basin. It is in clearing up and solving just such important, practical, geological problems as these that the State is to derive so much benefit from a thorough detailed survey of its coal fields.

In the hills in the neighborhood of Hawesville, I obtained tolerably satisfactory sections of two hundred and seventy feet of the strata overlying the main Hawesville coal, which show four beds of coal; the first above the main Hawesville coal, being nineteen inches thick, the second eight inches, the third sixteen inches, the fourth thirty-five inches. None of these coals correspond either in quality of coal, thickness, roof or position above the sub-carboniferous limestone, to the Breckinridge coal.

Sections obtained at the Reverdy and Lemon coal banks, and borings made under the Cannelton coal have made us acquainted with one hundred and ninety feet of the strata underlying the main Hawesville bed, in the immediate valley of the Ohio, showing one bed of coal of ten inches, and two "coal dusts" of eighteen and twenty inches each. The space between the eighteen-inch coal dust and the limestone underlying the conglomerate is within a few feet of the distance between the Breckinridge coal and an apparently corresponding limestone; hence the inference which has led to consider this to be probably the place of the Breckinridge coal.

In a former part of this report I had occasion to bring forward proof of the denudation of carboniferous strata in the vicinity of conglomerate.

Half a mile above Hawesville fifty feet of conglomerate presents itself near the base of the hills, affording evidence of currents flowing in the course of the bed of the Ohio valley, which may lend probability to the idea of these "coal dusts" being either eroded coal beds swept by these currents, or the debris of coal beds re-deposited not far from their original position.

The following is an average of four analyses of the Breckinridge coal:

| | | |
|---|---|---|
| Specific gravity, | 1.339 | |
| Total volatile matter, | | 63.87 |
| Coke, (unchanged in form,) | | 36.13 |
| | | 100.00 |
| Moisture, | 1.44 | |
| Volatile combustible matter, | 62.40 | |
| Fixed carbon in coke, | 28.20 | |
| Ashes, (fawn colored,) | 7.96 | |
| | 100.00 | |

The Breckinridge coal exceeds, in the amount of volatile matter, any coal which has yet been analysed from Kentucky—containing even more than the Hillsboro coal, of Nova Scotia, or the Cuba Asphaltum; and an analysis of Breckinridge coal recently sent me from the mines, gives, within a fraction of a per cent., as much volatile matter as the Boghead coal, of Scotland, hitherto considered the most productive in oily and waxy products.

The experiments which we have made upon the Breckinridge coal prove, however, that not only the amount of volatile matter varies very much, but also the nature of the volatile products vary with the degree of heat employed, and the rapidity with which that heat is applied. If the heat is moderate and gradual, the quantity of the liquid hydro-carbons or of oily products are greatly increased, at the expense of the permanent gaseous carburetted hydrogen.

By operating on half a pound of the Breckinridge coal at low and very gradually increasing heat, we obtained,

| | *Ounces.* | *Grammes.* | *Per cent.* |
|---|---|---|---|
| Of crude oils, | 3.25 — | 77.20 — | 30.6 |
| Ammoniacal liquid, | .50 — | 14.97 — | 5.4 |

The crude oils, by standing, separated into two distinct products, of different specific gravity—a light oil of deep red color, having a boiling point of 198°, weighing two ounces; and a gelatinous or crystalline mass of the consistence of magilp, weighing 1.25 ounces. This last contains an oil, (naphthaline?) and a waxy product, either paraffine or paranaphthaline—most likely the latter; but we have not yet had time thoroughly to investigate its properties or composition. The total amount of crude oils which this coal yielded, from an experiment even on this small scale, would be equal to a little over one hundred gallons to the ton of Breckinridge coal of two thousand pounds.

By simple distillation the light oil (eupion) can be partially purified, and subsequent treatment with sulphuric acid, caustic potash, and redistillation render it almost colorless; it has the odor of naptha, is very limpid, and can be burned in lamps with high chimneys and good draft.

In connection with this subject I would here remark, that though we know, from having detected unequivocal organic structure in coal, by aid of the microscope, that it is derived from wood, so that we can even, in some instances, refer to the very tribe of plants from which it has been produced; and though we are acquainted with the ultimate elements of which the coal is composed, and numerous proximate principles which can be extracted from coal by causing these elements to unite in different proportions, by various modes of destructive distillation, and other chemical processes; and though we can trace certain analogies in the changes which moist vegetable matter undergoes, before our eyes, by smothered combustion, or by exposure to an elevated temperature, under pressure and out of contact of air, still we have a great deal to learn, both from chemistry, fossil botany, and geology, before we can understand fully the precise changes which have taken place. How such a vast amount of vegetable organisms can have accumulated; how much of the multiplicity of shades of difference discoverable in the composition of coals, and the infinite variety in the quantity and quality of the proximate constituents they yield, is attributable to peculiarities in the various extinct genera of plants from which they have been derived; how much is due to modifications in the fossilizing process, and how much to temperature, particularly when we can observe very decided and remarkable local differences in chemical composition in the same bed of coal, even in short distances along its range.

The following is an analysis of the main Hawesville coal, specimen taken from the new entry made by the Messrs. Hawes, of Hancock county:

| | | |
|---|---|---|
| Specific gravity, | 1.397 | |
| Total volatile matter, | | 47.0 |
| Coke, (swells up slightly in coking, with a slight disposition to cake,) | | 53.0 |
| | | 100.0 |
| Moisture, | 8.0 | |
| Volatile combustible matter, | 39.0 | |
| Fixed carbon in coke, | 46.0 | |
| Ashes, (white,) | 7.0 | |
| | 100.0 | |

For rapidity of ignition this coal takes a high rank, bringing a boiler into steady action in about half an hour. For completeness of combustion, or freedom from waste in burning, it takes rank far above the average of coals, leaving only about 6.5 to seven pounds of unburnt coke in the grate, when, under the same circumstances, Pittsburg coal leaves over nine pounds; Cumberland coal over forty-three pounds, and Beaver Meadow from one hundred and seven to one hundred and twelve pounds. For maximum rapidity of evaporation it also ranks above the average of coals, converting into steam, in one hour, 15.5 cubic feet of water, while Pittsburg coal, under the same circumstances, only evaporated 10 cubic feet, and Beaver Meadow 13.47 cubic feet. In consequence, however, of the amount of fixed carbon being several per cent. below that in the Pittsburg coal, it falls below that fuel in evaporative power, under *equal weights*, i. e. one pound of Hawesville coal will evaporate 7.34 pounds of water at 212°, while one pound of Pittsburg coal will evaporate 8.2 pounds.

An abrupt dislocation and fault of the Coal Measures between the upper and lower Trabue entries, elevates the main Hawesville coal abruptly from sixty to seventy feet. This up-cast, together with the north-westerly dip of the measures, brings the main coal, approximately, from eighty feet, which is above low water at the Trabue entry, to one hundred and seventy feet above the same level at the upper Trabue entry, while at the Cooper entry it is fifty-five feet; about thirty feet? at the Mahan & Tyler entry; thirty feet below low water at the New Hawes entry; and seventy to eighty feet below low water on the Indiana shore, near Judge Huntingdon's residence, where the nineteen-inch coal, overlaid by black shale, lies within five feet of low water. Above Hawesville, at the Reverdy entry, the same bed is elevated one hundred and eighty-three feet above low water, and at the Lemon entry, a little higher up, on the Indiana side, it is one hundred and ninety feet, and two hundred and fourteen feet at a cliff, (in Mockasin track ridge?) about half a mile still farther up the river; at Cannelton it is one hundred and sixty-five feet above low water.

At these different openings the coal varies from two feet and a half to three feet ten inches or four feet. It has usually a roof of sandstone, with interpolations of shale ("grey metal,") which passes, however, locally into indurated argillaceous shale, in this respect corresponding with the Bell coal of the Tradewater country, in Union county. By approximate measurement it lies from one hundred and forty to one hundred and fifty feet above the top of the conglomerate, and about two hundred feet above the limestone underlying the conglomerate in this space. As previously remarked, no workable coal has yet been detected in the immediate vicinity of the Ohio; only two "coal dusts" of eighteen and twenty inches each, and a ten-inch coal, the intervening spaces being from forty to sixty feet. One, or perhaps two, of these will, I believe, be found to be workable beds, followed in the line of dip further within the coal field, and even along the strike-line, remote from the course of the currents which swept locally over these Lower Coal Measures, and ultimately transported the coarse sand and pebbles which went to form the conglomerates.

In the two hundred and ten feet of space lying in the hills above where the main Hawesville coal has sunk below the level of low water of the Ohio river, four beds of coal have been noticed, as heretofore alluded to, of 19.8, 16, and 31 inches in thickness, in the ascending order—the lowest being seventy-five to eighty-five feet above the main coal, the other spaces being 21.5, 68.5, and 31.5 feet. The top hill, or thirty-one-inch coal, has a clay parting of one foot, and may possibly be two beds, which diverge and become distinct in the interior of the coal field. This bed is overlaid by nine feet of limestone, with the interposition of two feet of shale between it and the coal. The twenty feet of shale immediately overlying the eight-inch coal, contains considerable quantities of clay ironstones. This coal and shale, with ironstone, may perhaps prove to be the eastern representative of the "Ice House" coal, shale, and ironstone, of Union county. This remark I throw out, at present, as a mere suggestion for future investigation.

The upper bed of coal, overlaid by limestone, shows itself on Lead creek, in Hancock county, about one hundred and five feet above a fourteen-inch band of ironstone in its bed; also, on the Stump branch of Yellow creek, where there is a band of ironstone two to two and a half inches, struck in a well sunk by Robert Estis.

In Hancock county, five miles west of Hawesville, is the Estis coal drift, which measures from four feet three to four feet four inches, covered by black bituminous shale containing fossil Productus converted into pyrites. The coal, at its entrance, has two thin bands of pyrites. Some calcareous masses were noticed here, which are probably segregations fallen out of the shaly roof of the coal.

At the main Lewisport entry, one and a half miles from the Ohio river, the coal measured three feet five to three feet one inch. About forty-five feet below the main coal there appears to be another coal of some sixteen inches in thickness. The absence of all solid rock above the Lewisport coal, or good sections below it, renders it difficult to decide on its true geological position. If, when it is fairly entered, there should prove to be a solid bed of limestone over the shale, then it may be the upper member of the top hill coal above the Hawes entry; but, if so, greatly increased in thickness in its westward extension.

From what I know of the geology of Spencer county, Indiana, and from a comparison of the western side of the basin, I am induced to believe that a thorough detailed survey will develope other beds of coal in the western part of Hancock county not at present known. Six or eight feet below the bed of the Sulphur fork of Blackford's creek, a hard coal has been struck, probably equivalent to the Breckinridge coal; also, about eight miles south of Hawesville, on the Caney fork of Blackford, two to two and a half-foot of coal is said to lie under sandstone; also, another thicker coal, three-quarters of a mile from that locality. One mile east of Knottsville, in Daviess county, a thin coal was observed; a few inches of coal were also seen, between sandstone, just west of Pellville, in the same county.

Three miles west of Pellville two feet ten inches of coal is said to crop out under sandstone. Coal of the same thickness is obtained by the blacksmiths in Knottsville, three miles west of that place, and two miles north of the Owensboro road, which they prefer to any other coal in that neighborhood. There are also some out-crops of coal on Puppy creek, said to be of good workable thickness. Two miles north-east of Knottsville, a coal known as Head's coal is said to be three feet thick, and considered good by the blacksmiths; and four miles east of Knottsville a four-foot coal is reported. These I have, as yet, had no opportunity of investigating personally.

The dislocation of the Coal Measures, with the protrusion of millstone grit, and some members of the sub-carboniferous limestone, which I mention as occurring on Barnett's creek, in Ohio county, I think will be found to extend north into Daviess, passing somewhere near Jack May's farm. One mile west of this, three feet and a half of coal, overlaid by black shale, was passed through in sinking a well, at the depth of twenty-eight feet.

In consequence of these localities lying along the above mentioned zone of disturbance, and the absence of good sections of the rocks along the line of my observation through this part of Daviess, it is impossible, at present, to give any definite opinion in regard to the place which these coals occupy in the Coal Measures.

The long reach of the Ohio river, where no bluffs come up, on either the Kentucky or Indiana shore, below the point where the Rockport sandstone disappears to the mouth of Pigeon river, is, no doubt, occupied by the great mass of shales and soft materials that underlie and overlie the Bonharbor coal, and include, besides that coal, the thirteen-inch Coal-Haven coal and the three-foot and a half coal reached in the Henderson shaft, about two hundred feet below the bed of the Ohio river.

## COAL MEASURES

## *Of Greenup, Carter, and Lewis counties, of the Eastern Coal Field.*

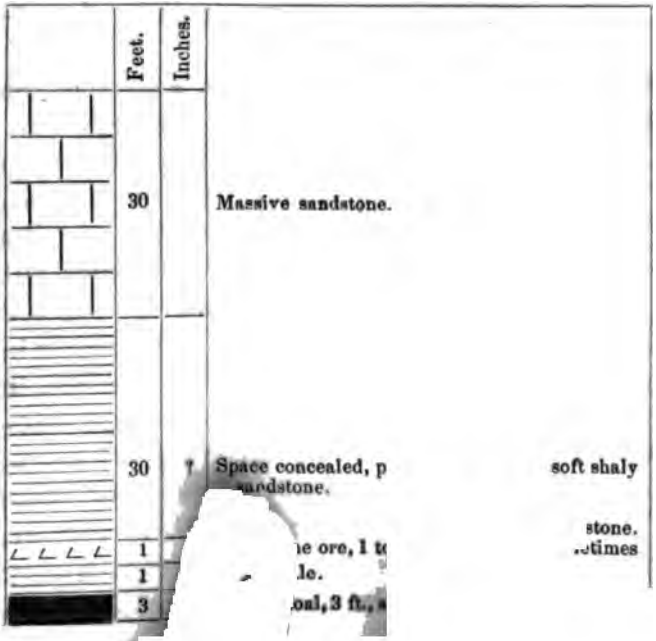
Diagram No. 3 exhibits the succession of the Coal Measures of Greenup and Carter counties, from the sub-carboniferous limestone of Tygert's creek to the height of seven hundred and forty feet, up to the Rough and Ready ore bank, that supplies the Sandy furnace. In those seven hundred and forty feet there are no less than fourteen distinct ore beds interstratified in the Coal Measures, having a thickness of from three or four inches to four feet, and varying in their yield of metallic iron from twenty-five to sixty per cent. from the raw ore. They belong mostly to the group of limonites (hematitic) or hydrated brown oxydes of iron, and to the carbonates of the protoxide of iron; and one of those which have been analyzed from the East fork of Little

two or three feet of limestone. It seems to run out at the top of the hills about one and a half miles south-west of the place where it is dug for the use of the Sandy furnace; the underlying limestone reaches the tops of the hills about half a mile still further south-west. The prevalent dip of the rocks is south of east.

Some few fossil *Producta* and *Spirifer* occur in the green rock associated with the soft ore. The space between the lower and upper limestone is mostly filled with coarse sandstone.

A coal, from three and a half to four feet in thickness, occurs in the valley of Little Sandy, fifteen to twenty feet above its bed, and a mile or two from the Mt. Savage iron works. This bed has two clay partings, of two to three inches thick; one about one foot from the bottom of the coal, and the other four inches from the top. The roof is grey argillaceous shale, passing into argillaceous sandstone. The lower part of this coal is of good quality. It is probably the equivalent of the main Ashland coal.

The principal ore banks that supply the Mt. Savage furnace are the Stinson ore banks, situated high in a hill to the north-east, on a branch of the same name, some fifty to sixty feet below where the road crosses this ridge. A bed of cannel coal is associated with the ore beds approximately, thus:



| | Feet. | Inches. | |
|---|---|---|---|
| | 30 | | Massive sandstone. |
| | 30 | ? | Space concealed, p soft shaly sandstone. stone. |
| | 1 | | e ore, 1 t ..times |
| | 1 | | le. |
| | 3 | | oal, 3 ft., |

Some minor ore beds occur in the hills nearer to the furnace; one associated with a shale that lies some thirty feet above the main coal, with two clay partings, and one ninety to one hundred feet above the same coal. There are probably two other ore beds lying in the in-

The pig-iron produced from these ores yielded, by analysis,

| | |
|---|---|
| Metallic iron, | 91.000 |
| Combined carbon, | 2.570 |
| Graphite, | 3.200 |
| Carbonaceous matter, extracted by potash, | 0.250 |
| Silica, | 1.050 |
| Phosphorus, | 0.350 |
| Chromium, | 0.147 |
| Alkalies, | 0.260 |
| | 98.827 |

This iron is not very tough, but remarkably liquid, and therefore suitable for fine castings.

This furnace can make about seven tons of iron in twenty-four hours. It is situated eight miles from their depot, at Cattlettsburg, and twenty-two miles, by the course of the stream, above the mouth of the East fork of Little Sandy river.

There are two or three beds of limestone in the section near the furnace, one of which lies in the bed of Bolt's fork, and another usually under an ore bed one hundred and five feet higher in the hills. On the opposite side of the ravine, north of the furnace, there is an impure limestone at about seventy-five feet above Bolt's fork, which may, however, be the same limestone. The ridges here are from one hundred and twenty-five to one hundred and seventy-five feet above the general drainage.

A coarse ferruginous sandstone, probably the equivalent of the top hill pebbly sandstone, at the Catlettsburg section, overlies the lower limestone. It is employed as hearth-stones for the furnace. A thin coal of some fifteen inches is interposed between it and the lower limestone. The lowest ground seems to be underlaid by greenish argillaceous shales, which have been thrown out of excavations for wells.

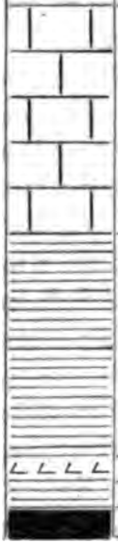
The "Rough and Ready ore bed" is high in the hill, under a hard sandstone, with the intervention of 5.5 feet of yellow ferruginous, argillaceous shale. The ore varies from eight to thirteen inches in thickness, and runs, in some places, even as high as two feet; but, in such cases, it has a heavy green calcareous rock mixed with it, and the ore is not as good as when it is thinner and disconnected with the green rock. It is generally regarded as the highest workable ore bed in Carter and Lawrence counties. This ore is sometimes underlaid by

two or three feet of limestone. It seems to run out at the top of the hills about one and a half miles south-west of the place where it is dug for the use of the Sandy furnace; the underlying limestone reaches the tops of the hills about half a mile still further south-west. The prevalent dip of the rocks is south of east.

Some few fossil *Producta* and *Spirifer* occur in the green rock associated with the soft ore. The space between the lower and upper limestone is mostly filled with coarse sandstone.

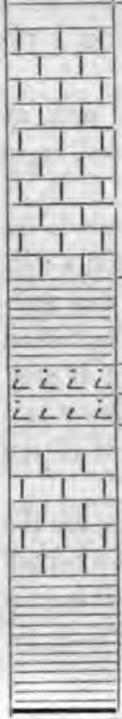
A coal, from three and a half to four feet in thickness, occurs in the valley of Little Sandy, fifteen to twenty feet above its bed, and a mile or two from the Mt. Savage iron works. This bed has two clay partings, of two to three inches thick; one about one foot from the bottom of the coal, and the other four inches from the top. The roof is grey argillaceous shale, passing into argillaceous sandstone. The lower part of this coal is of good quality. It is probably the equivalent of the main Ashland coal.

The principal ore banks that supply the Mt. Savage furnace are the Stinson ore banks, situated high in a hill to the north-east, on a branch of the same name, some fifty to sixty feet below where the road crosses this ridge. A bed of cannel coal is associated with the ore beds approximately, thus:



| Feet. | Inches. | |
|---|---|---|
| 30 | | Massive sandstone. |
| 30 | ? | Space concealed, probably shale and soft shaly sandstone. |
| 1 | | Limestone ore, 1 to 3 feet, replaced sometimes by limestone. |
| 1 | 6 | Grey shale. |
| 3 | | Cannel coal, 3 ft., said sometimes to be 5 ft. thick |

Some minor ore beds occur in the hills nearer to the furnace; one associated with a shale that lies some thirty feet above the main coal, with two clay partings, and one ninety to one hundred feet above the same coal. There are probably two other ore beds lying in the in-



| Feet. | Inches. | |
|---|---|---|
| 30 | | Sandstone. |
| 10 | | Ash-colored argillaceous shale. |
| 1 | | Kidney ore, 4 inches to 1 foot thick. |
| | 8 | Rough block ore, 3 to 8 inches. |
| | | Space, with sandstone and shale down to next coal, some 25 to 40 feet. |

tervening space, judging from observations made further north, in Greenup county.

The Mt. Savage furnace, owned by R. M. Biggs & Co., runs generally about nine and a half tons of iron in twenty-four hours, and sometimes as much as seventy tons per week. About sixty or seventy pounds of limestone are used to nine hundred pounds of roasted ore.

For chemical analyses of two of the principal ores smelted at the Mt. Savage furnace, see No. 17 and 18 of Dr. Peter's Report.

The main coal at the Star furnace lies about one hundred and ten feet below the top of the ridge containing the ore. It is five feet ten inches, including two clay partings. A bed of yellow kidney ore lies twenty feet below this coal, and another bed of similar ore thirty feet above it. From this to the top of the ridge, in which the coal and ore lie, is eighty feet. Other more elevated ridges are seen, however, in the distance. I should expect to find at least two other ore beds in the above eighty or one hundred feet of the tops of these ridges—one about fifty feet above the coal, and the other skimming the tops of the minor ridges. On an average about fifty pounds of limestone are added to flux nine hundred and fifty pounds of the roasted ore, used at the Star furnace. When the charge is altogether the Kidney ore, only about forty pounds of limestone are employed. There is a species of limestone ore sometimes used at this furnace; when this forms a considerable part of the charge little or no limestone is required. The Star furnace (Lampton, Riley, & Co.,) averages about ten or ten and a half tons in twenty-four hours, and sometimes as high as twelve tons.

At the Buena Vista furnace there is also a coal with the same clay partings in the hills, but the precise thickness could not be seen at the time I examined it. Twenty feet under the coal, on the same geological horizon as the lower yellow kidney ore, at the Star furnace, is a bed of very dark colored ore. The best kidney ore lies associated with green ash-colored shales thirty feet above the coal, as at the Star furnace. Ten feet higher is a brownish-grey earthy "limestone ore; and twenty feet higher, or sixty feet above the coal, is the "top hill ore," within fifteen or twenty feet of the average height of the ridges in this vicinity. Skimming the tops of higher ridges there is still another variety of ore—"Blue Kidney ore." Locally there is also a "Blue Block ore," low down in the hills, lying sometimes above and sometimes below a thin lower bed of coal, making six beds in all between the creek bottoms and the tops of the hills.

The Buena Vista furnace (H. Mears & Co.,) runs about ten tons of iron in twenty-four hours, when in good blast.

A third bed of coal occurs on Williams creek, and in the cut of the Big Sandy and Lexington railroad, covered by ten or fifteen feet of shale, on which reposes a sandstone suitable for building purposes and hearth-stones. This coal lies some fifty or sixty feet below the "Blue Block ore," and associate coal of the Buena Vista ore banks. It is locally divided into three members by intervening strata of shale and shaly sandstone. (For analyses of the ores, pig-iron, and furnace-slag of the Buena Vista furnace, see Dr. Peter's Report, Nos, 44, 45, 46, 47, and 48.)

The principal ores worked at the Clinton furnace are: a top hill, fossiliferous "limestone ore," (No 119 of Dr. Peter's Report;) a carbonate of iron, of a dark grey color internally, with a yellow, reddish, ochreous appearance externally, and granular or confusedly crystalline structure, (No. 120 of Dr. Peter's Report;)—this ore is drifted after, and varies from one and a half to three feet in thickness; a black band ore, averaging about one foot in thickness under the coal, (No. 121 of Dr. Peter's Report;) and a green "limestone ore," (No. 122

east of Knottsville, a coal known as Head's coal is said to be three feet thick, and considered good by the blacksmiths; and four miles east of Knottsville a four-foot coal is reported. These I have, as yet, had no opportunity of investigating personally.

The dislocation of the Coal Measures, with the protrusion of millstone grit, and some members of the sub-carboniferous limestone, which I mention as occurring on Barnett's creek, in Ohio county, I think will be found to extend north into Daviess, passing somewhere near Jack May's farm. One mile west of this, three feet and a half of coal, overlaid by black shale, was passed through in sinking a well, at the depth of twenty-eight feet.

In consequence of these localities lying along the above mentioned zone of disturbance, and the absence of good sections of the rocks along the line of my observation through this part of Daviess, it is impossible, at present, to give any definite opinion in regard to the place which these coals occupy in the Coal Measures.

The long reach of the Ohio river, where no bluffs come up, on either the Kentucky or Indiana shore, below the point where the Rockport sandstone disappears to the mouth of Pigeon river, is, no doubt, occupied by the great mass of shales and soft materials that underlie and overlie the Bonharbor coal, and include, besides that coal, the thirteen-inch Coal-Haven coal and the three-foot and a half coal reached in the Henderson shaft, about two hundred feet below the bed of the Ohio river.

## COAL MEASURES

### *Of Greenup, Carter, and Lewis counties, of the Eastern Coal Field.*

Diagram No. 3 exhibits the succession of the Coal Measures of Greenup and Carter counties, from the sub-carboniferous limestone of Tygert's creek to the height of seven hundred and forty feet, up to the Rough and Ready ore bank, that supplies the Sandy furnace. In those seven hundred and forty feet there are no less than fourteen distinct ore beds interstratified in the Coal Measures, having a thickness of from three or four inches to four feet, and varying in their yield of metallic iron from twenty-five to sixty per cent. from the raw ore. They belong mostly to the group of limonites (hematitic) or hydrated brown oxydes of iron, and to the carbonates of the protoxide of iron; and one of those which have been analyzed from the East fork of Little

Sandy, near the Lexington and Big Sandy railroad, since it contains 11.1 per cent. of bituminous matter, may be classed with the richer varieties of black band ore of Mushet, which are so well suited for the manufacture of cheap iron with raw coal and the hot air blast. It contains 32.37 per cent. of metallic iron, and will average a foot in thickness. One of the ores used at the Sandy furnace is remarkably calcareous, containing twenty-one per cent. of lime, so that, even when mixed with other ore containing little or no lime, it is unnecessary to add any limestone as a flux.

The composition of this ore is,

| | | | |
|---|---|---|---|
| Specific gravity, | | | 2.8121 |
| Water, | 2.70 | | |
| Carbonic acid, | 18.80 | Silica, | 20.6 |
| Insoluble silicates, | 25.60 | Alumina tinged with oxyde of iron, | 5.0 |
| Silica dissolved by hydrochloric acid, | .490 | | |
| Peroxide of iron, | 16.744 | 13.65 iron. | |
| Protoxide of iron, | 2.480 | | |
| Lime, | 21.800 | | |
| Magnesia, | .400 | | |
| Alumina, | 6.500 | | |
| Soda, | 2.500 | | |
| Potash, | .660 | | |
| Phosphoric acid, | .800 | | |
| Sulphur, | .013 | | |
| Chromium, a trace, and loss, | .513 | | |
| | 100.000 | | |

The top hill ore, which is mixed with the above ore, yielded,

| | | |
|---|---|---|
| Water, | 7.3 | |
| Peroxide of iron, | 61.0 | — 42.7 iron. |
| Alumina, | 13.9 ? | |
| Alkali, | 0.5 | |
| Insoluble silicates, | 16.9 | |
| Loss, | .4 | |
| | 100.0 | |

These two ores, mixed half and half, will yield 28.17 of iron, and 10.4 per cent. of lime. (See Dr. Peter's Report, Nos. 13 and 14, for other analyses of ores used at the Sandy furnace.)

The pig-iron produced from these ores yielded, by analysis,

| | |
|---|---|
| Metallic iron, | 91.000 |
| Combined carbon, | 2.570 |
| Graphite, | 3.200 |
| Carbonaceous matter, extracted by potash, | 0.250 |
| Silica, | 1.050 |
| Phosphorus, | 0.350 |
| Chromium, | 0.147 |
| Alkalies, | 0.260 |
| | 98.827 |

This iron is not very tough, but remarkably liquid, and therefore suitable for fine castings.

This furnace can make about seven tons of iron in twenty-four hours. It is situated eight miles from their depot, at Cattlettsburg, and twenty-two miles, by the course of the stream, above the mouth of the East fork of Little Sandy river.

There are two or three beds of limestone in the section near the furnace, one of which lies in the bed of Bolt's fork, and another usually under an ore bed one hundred and five feet higher in the hills. On the opposite side of the ravine, north of the furnace, there is an impure limestone at about seventy-five feet above Bolt's fork, which may, however, be the same limestone. The ridges here are from one hundred and twenty-five to one hundred and seventy-five feet above the general drainage.

A coarse ferruginous sandstone, probably the equivalent of the top hill pebbly sandstone, at the Catlettsburg section, overlies the lower limestone. It is employed as hearth-stones for the furnace. A thin coal of some fifteen inches is interposed between it and the lower limestone. The lowest ground seems to be underlaid by greenish argillaceous shales, which have been thrown out of excavations for wells.

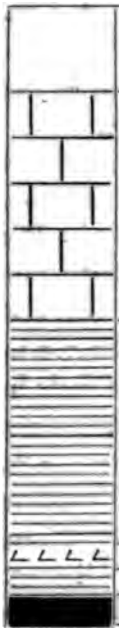
The "Rough and Ready ore bed" is high in the hill, under a hard sandstone, with the intervention of 5.5 feet of yellow ferruginous, argillaceous shale. The ore varies from eight to thirteen inches in thickness, and runs, in some places, even as high as two feet; but, in such cases, it has a heavy green calcareous rock mixed with it, and the ore is not as good as when it is thinner and disconnected with the green rock. It is generally regarded as the highest workable ore bed in Carter and Lawrence counties. This ore is sometimes underlaid by

two or three feet of limestone. It seems to run out at the top of the hills about one and a half miles south-west of the place where it is dug for the use of the Sandy furnace; the underlying limestone reaches the tops of the hills about half a mile still further south-west. The prevalent dip of the rocks is south of east.

Some few fossil *Producta* and *Spirifer* occur in the green rock associated with the soft ore. The space between the lower and upper limestone is mostly filled with coarse sandstone.

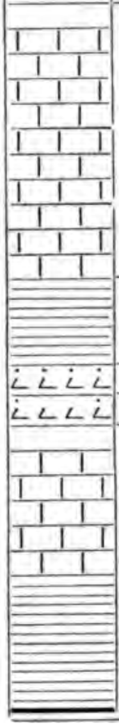
A coal, from three and a half to four feet in thickness, occurs in the valley of Little Sandy, fifteen to twenty feet above its bed, and a mile or two from the Mt. Savage iron works. This bed has two clay partings, of two to three inches thick; one about one foot from the bottom of the coal, and the other four inches from the top. The roof is grey argillaceous shale, passing into argillaceous sandstone. The lower part of this coal is of good quality. It is probably the equivalent of the main Ashland coal.

The principal ore banks that supply the Mt. Savage furnace are the Stinson ore banks, situated high in a hill to the north-east, on a branch of the same name, some fifty to sixty feet below where the road crosses this ridge. A bed of cannel coal is associated with the ore beds approximately, thus:



| Feet. | Inches. | |
|---|---|---|
| 30 | | Massive sandstone. |
| 30 | ? | Space concealed, probably shale and soft shaly sandstone. |
| 1 | | Limestone ore, 1 to 3 feet, replaced sometimes [by limestone. |
| 1 | 6 | Grey shale. |
| 3 | | Cannel coal, 3 ft., said sometimes to be 5 ft. thick |

Some minor ore beds occur in the hills nearer to the furnace; one associated with a shale that lies some thirty feet above the main coal, with two clay partings, and one ninety to one hundred feet above the same coal. There are probably two other ore beds lying in the in-



| Feet. | Inches. | |
|---|---|---|
| 30 | | Sandstone. |
| 10 | | Ash-colored argillaceous shale. |
| 1 | | Kidney ore, 4 inches to 1 foot thick. |
| | 8 | Rough block ore, 3 to 8 inches. |
| | | Space, with sandstone and shale down to next coal, some 25 to 40 feet. |

tervening space, judging from observations made further north, in Greenup county.

The Mt. Savage furnace, owned by R. M. Biggs & Co., runs generally about nine and a half tons of iron in twenty-four hours, and sometimes as much as seventy tons per week. About sixty or seventy pounds of limestone are used to nine hundred pounds of roasted ore.

For chemical analyses of two of the principal ores smelted at the Mt. Savage furnace, see No. 17 and 18 of Dr. Peter's Report.

The main coal at the Star furnace lies about one hundred and ten feet below the top of the ridge containing the ore. It is five feet ten inches, including two clay partings. A bed of yellow kidney ore lies twenty feet below this coal, and another bed of similar ore thirty feet above it. From this to the top of the ridge, in which the coal and ore lie, is eighty feet. Other more elevated ridges are seen, however, in the distance. I should expect to find at least two other ore beds in the above eighty or one hundred feet of the tops of these ridges—one about fifty feet above the coal, and the other skimming the tops of the minor ridges. On an average about fifty pounds of limestone are added to flux nine hundred and fifty pounds of the roasted ore, used at the Star furnace. When the charge is altogether the Kidney ore, only about forty pounds of limestone are employed. There is a species of limestone ore sometimes used at this furnace; when this forms a considerable part of the charge little or no limestone is required. The Star furnace (Lampton, Riley, & Co.,) averages about ten or ten and a half tons in twenty-four hours, and sometimes as high as twelve tons.

At the Buena Vista furnace there is also a coal with the same clay partings in the hills, but the precise thickness could not be seen at the time I examined it. Twenty feet under the coal, on the same geological horizon as the lower yellow kidney ore, at the Star furnace, is a bed of very dark colored ore. The best kidney ore lies associated with green ash-colored shales thirty feet above the coal, as at the Star furnace. Ten feet higher is a brownish-grey earthy "limestone ore; and twenty feet higher, or sixty feet above the coal, is the "top hill ore," within fifteen or twenty feet of the average height of the ridges in this vicinity. Skimming the tops of higher ridges there is still another variety of ore—"Blue Kidney ore." Locally there is also a "Blue Block ore," low down in the hills, lying sometimes above and sometimes below a thin lower bed of coal, making six beds in all between the creek bottoms and the tops of the hills.

The Buena Vista furnace (H. Mears & Co.,) runs about ten tons of iron in twenty-four hours, when in good blast.

A third bed of coal occurs on Williams creek, and in the cut of the Big Sandy and Lexington railroad, covered by ten or fifteen feet of shale, on which reposes a sandstone suitable for building purposes and hearth-stones. This coal lies some fifty or sixty feet below the "Blue Block ore," and associate coal of the Buena Vista ore banks. It is locally divided into three members by intervening strata of shale and shaly sandstone. (For analyses of the ores, pig-iron, and furnace-slag of the Buena Vista furnace, see Dr. Peter's Report, Nos, 44, 45, 46, 47, and 48.)

The principal ores worked at the Clinton furnace are: a top hill, fossiliferous "limestone ore," (No 119 of Dr. Peter's Report;) a carbonate of iron, of a dark grey color internally, with a yellow, reddish, ochreous appearance externally, and granular or confusedly crystalline structure, (No. 120 of Dr. Peter's Report;)—this ore is drifted after, and varies from one and a half to three feet in thickness; a black band ore, averaging about one foot in thickness under the coal, (No. 121 of Dr. Peter's Report;) and a green "limestone ore," (No. 122

of Dr. Peter's Report,) containigg 25.68 per cent. of iron. There is also a "nodular kidney ore," lying forty or fifty feet above the coal.

The main coal, on the Clinton furnace property, is four feet in thickness, with a clay parting, two feet seven inches from the bottom, one inch - thick. This is the equivalent of the main Ashland coal, of which an analysis is given in the first chapter. It lies, by the railroad levels, one hundred and seventy feet above low water of the Ohio river, and about six hundred and fifty feet above tide water. An inferior bed of coal was struck in sinking a well at the Clinton furnace, reported to be six feet thick, but it is, in all probability, the equivalent of the three-membered coal laid bare in the railroad cut near Welsh's, so that it is probable that considerable clay partings are included in this thickness. This coal lies about fifty feet below the main coal, and about one hundred and twenty feet above low water of the Ohio river, and about six hundred feet above tide water.

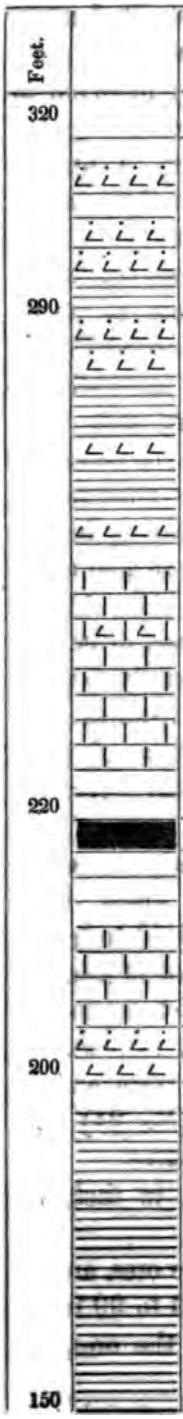
The various ores smelted at the Clinton furnace will average about thirty per cent. from the *raw* ore, and about forty per cent. from the roasted ore.

The Clinton cold-bast furnace (J. Burwell & Co.,) can run about nine tons of pig-iron in twenty-four hours.

The main ore bed worked at the Bellefonte furnace overlies a bed of limestone that has an extensive range through the upper part of the adjacent hills; it varies in thickness from one to three and a half or four feet, imbedded in a dark ash-colored shale. At the out-crop it is mostly hydrated oxyde of iron, (limonite,) but the further the ore is worked into the hills the less there is of this variety, and the more of proto-carbonate of iron. There is another "blue limestone ore," which lies under a sandstone at a lower level. (For the analyses of these ores, the limestone used as a flux, the furnace slag, and pig-iron produced at the Bellefonte furnace, see Dr. Peter's Report, Nos. 49 to 53 inclusive.) These ores will yield, on an average, thirty-one per cent. from the raw ore.

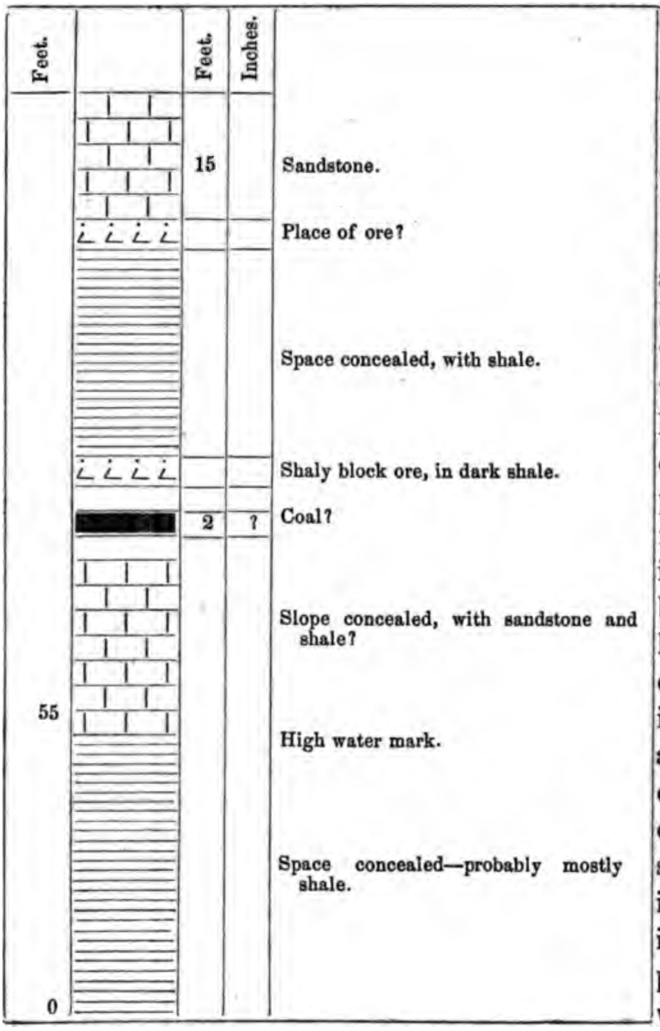
The Bellefonte cold-blast furnace, (T. W. & H. Means & Co.,) makes about eight tons of iron in twenty-four hours. About forty pounds of limestone are used to flux eight hundred and fifty pounds of roasted ore.

Five to six beds of ore are found in the hills bordering on the Ohio river, near the Amanda furnace, as represented in the following section:



| Feet. | Inches. | |
|---|---|---|
| | | Top of ridge—about 800 feet above tide water. |
| 20 | | Space, with ferruginous shale and "top hill kidney ore." |
| 60 | | "Yellow kidney ore," in nests in the ferruginous shale.<br>Schistose sandstone? |
| 4 | | Upper main coal of the Amanda section, with clay parting of 2 to 3 inches. |
| | | Space concealed, with shale and sandstone. |
| 1 | | "Limestone ore." |
| 4 | | Limestone. |
| 2 | 6 | Fire clay. |
| 43 | | Space concealed—mostly shales? |

The principal ore beds lie at an elevation of two hundred and ninety and three hundred and ten feet above low water of the Ohio river, lying in nests disseminated in ferruginous shales. The "blue block ore," associated with dark shales, lying at an elevation of ninety-five feet above low water of the Ohio river, is not much used, as it is regarded as being too silicious and impracticable at this locality. Dr. Peter's analysis of this ore, No. 97 of his report, only shows 9.64 per cent. of silica and insoluble silicates, which is not, by any means, a large proportion of these ingredients; indeed, as Dr. Peter sug-


Feet.
Feet.
Inches.
15
Sandstone.
Place of ore?
Space concealed, with shale.
Shaly block ore, in dark shale.
2
?
Coal?
Slope concealed, with sandstone and shale?
55
High water mark.
Space concealed—probably mostly shale.
0

gests, its impracticability is probably more due to its containing too small a proportion of the earthy materials to form a good cinder, and hence it melts too suddenly by the application of heat, and, without the necessary protection from a fluid slag, the iron is oxidated again by the blast; hence, to be successfully worked, it requires the addition of a more earthy ore, or of some of the shaly matter in which it is imbedded; in proof of this, ore which is considered to yield the best and toughest iron at the Amanda furnace, No. 96 of Dr. Peter's report, contains no less than 20.07 of silica and insoluble silicates, and the red and blue mixed block ore (No. 94) contains nearly twenty-five per cent. silica and insoluble silicates.

The various ores used at the Amanda furnace yield, in their raw state, 44.44 per cent. of iron.

For important additional information in regard to these ores, and resulting pig-iron, consult Dr. Peter's Report from Nos. 93 to 99 inclusive, where complete analyses will be found not only of the ores, but of the furnace slag and pig-iron.

The dark cinder, like bottle-glass, is producedat the Amanda furnace when the furnace is charged with "yellow kidney"—limonite ore, No. 93—and best "grey limestone ore," No. 96, when the furnace is then considered to be working well, and making good grey iron. The pea-green slag is produced generally when the "blue limestone" and "blue black ore," No. 97, is the furnace burthen, and there results white, high, close-textured pig-iron. Both good potters' clay and fire-clay are found in the hills near the Amanda furnace.

In following the ore beds into the hills it often happens that the ore bed and associated shales become pinched, and solid overlying and underlying rocks come closer together.

Near the Caroline furnace the main coal lies towards the base of the hills, and one hundred and forty to one hundred and fifty feet below the limestone on which the principal ore bed rests. The coal shows three feet of height, but there is only about two feet of good coal, as a clay parting runs through it, from eight inches to a foot in thickness.

The ores chiefly smelted at the Caroline furnace are the above mentioned "limestone ore," and a "top hill yellow kidney ore." At the Steam furnace, owned by the same firm, (Wurts, Swap & Co.,) the same kind of ores are employed, with an admixture of from one sixth to a fourth of "block ore."

The Caroline, which is a cold-blast furnace, makes from seven to eight tons in twenty-four hours, while the Steam furnace, which is a hot-blast, makes from one and a half to two tons more in twenty-four hours. The limestone used as a flux is added in the proportion of thirty to forty pounds to half a charge of seven hundred to eight hundred pounds.

In the hills between the Caroline and Steam furnaces there are very heavy beds of limestone, overlaid by three to four feet of ore.

At the Steam furnace the coal has a roof of black shale.

Of eight different varieties of ore smelted at the Pennsylvania furnace, that have been analyzed, six are essentially hydrated oxydes of iron, Nos. 31 to 36, of Dr. Peter's Report, and two carbonates, Nos. 37 and 38. These ores are mostly situated in the hills above the four-foot coal, with clay parting, which lies about thirty or forty feet above the bed of the East fork of Little Sandy river. There are four principal ore beds, besides several minor local beds: a "little block ore," four inches thick, situated thirty feet above the coal, and some ten to fifteen feet under a sandstone quarried for hearth-stones, containing from twenty-nine to thirty-five per cent. of iron, (No. 32 of Dr. Peter's Report;) a "rough block ore," considered of inferior quality, lying about one hundred and ten feet above the coal; a "limestone ore," averaging about eighteen inches in thickness, and situated about one hundred and thirty feet? above the coal, containing forty-two per cent. of iron, with a very large proportion of carbonate of lime, 20.67 per cent., (No. 33 of Dr. Peter's Report;) a rich limonite, (improperly called "limestone ore," merely because it overlies limestone,) containing 50.91 per cent. of iron, and *no* carbonate of lime, (No. 34 of Dr. Peter's Report)—the exact position this ore occupies in the hills I am, at present, unable to state; a "top hill ore," averaging eight inches, containing 38.23 per cent. of iron, and 13.85 of carbonate of lime, (No. 35 of Dr. Peter's Report;) a remarkably pure variety of limonite, (No. 36 of Dr. Peter's Report,) containing no less than 60.90 per cent of iron, no carbonate of lime, and only 3.47 of silica and insoluble silicates—this ore is considered impracticable at the works: this arises, evidently, from its very richness and purity, as heretofore remarked in the first chapter, and explained, also, in Dr. Peter's Report; a carbonate of iron, (No. 37 of Dr. Peter's Report,) four feet thick, overlying limestone, containing 39.42 per cent. of iron, 3.17 per cent. of carbonate of lime, and 9.47 per cent. of silica and insoluble silicates—also considered impracticable at the works. This ore also could, undoubtedly, be made to produce good iron if properly fluxed and managed, upon the principles explained in the first chapter, as it contains no injurious principle in sufficient quantity to deteriorate the quality of the iron; for instance: if mixed in due proportion with ores Nos. 32 and 33, with perhaps the addition of a little bituminous ferruginous schist or shale, and a small extra dose of limestone, so as to produce a good fluid lava of from thirty to forty per cent. the weight of the iron, that would protect and eliminate the reduced particles of metal, it could, in all probability, be worked successfully. The carbonate of iron, (No. 38 of Dr. Peter's Report,) also considered impracticable at the works, containing 41.80 per cent. of iron, 2.36 of carbonate of lime, and only 4.87 of insoluble silicates, only 0.04 of phosphoric acid, and a mere trace of sulphur, can also be made to yield good results by pursuing a similar plan. In this case it would require a larger addition of the earthy ore, No. 32, and ferruginous shale, to produce the normal scoria, from the fact of the amount of silica and insoluble silicates being 4.6 per cent. less than in No. 37. There is also a coarse "block ore" that lies low in the hills below the coal.

These eight varieties of ore average forty-two per cent. of iron, but the mixed ores that are *worked* only average thirty-eight. About one tenth of limestone is employed as a flux.

In the hills between the Pennsylvania and Greenup furnaces, a cannel coal lies under the "top hill ores"

The Pennsylvania hot-air-blast furnace, W. M. Patton & Co., runs about nine tons in twenty-four hours, or two thousand tons in nine months. For the composition of the limestone used as a flux, the furnace slag, pig-iron and coal, of the Pennsylvania furnace, see Nos. 39 to 43 inclusive of Dr. Peter's Report.

At the Greenup furnace there are two, if not three, beds of thin coal in the hills: a lower bed, near the drainage level, of eighteen inches, with a clay parting midway; an upper coal, nine inches. There is also said to be a bed of cannel coal, two and a half miles east of the furnace, about six feet above the creek level.

Seven varieties of ore (Nos. 69 to 76 of Dr. Peter's Report,) have been analyzed, from Greenup ore banks; five of these are hydrated oxydes, and two mixed carbonates of iron and oxyde of iron. The "big block ore," No. 70, is the richest in iron, yielding 47.69 per cent.: the poorest in iron is the "red ochre," No. 71, containing 18.62 per cent. Including this last ore in the calculation, the average per cent. of iron which the seven ores will yield, is 37.6, and leaving No. 71 out, 40.56. The proportion of limestone used as a flux is about one-tenth. For analyses of the limestone, furnace slag, and pig-iron, see Nos. 77, 78, and 79, of Dr. Peter's Report.

The Greenup hot-air-blast furnace, Wilson, Baird & Co., runs, on an average, about eight tons in twenty-four hours.

There is a yellow limestone ore, which occurs in the hills here, that must contain a large per centage of carbonate of lime, as it can be worked by itself, without any limestone as a flux.

The principal ores smelted at the Buffalo furnace lie high in the hills—the "main block ore" being from seventy to seventy-five feet above a six-inch coal, that lies some hundred and twenty-five feet up in the hills. The ore banks are from half a mile to two miles from the furnace.

Eight varieties of ore have been analyzed from the Buffalo ore banks—Nos. 54 to 61 inclusive, of Dr. Peter's Report. The last of these (No. 61) can, however, hardly be considered an ore, as it only contains 11.35 of iron, and 67.33 of carbonate of lime; it might answer, added in proper proportion, to flux the other ores, contributing, at the same time, the above per centage of iron to the furnace product. The variety of "main block ore," No. 58, yields the most iron (49.23,) though another variety, also labeled "main block ore," (No. 54,) of a dark-brown color, and compact structure, gives only 34.63. The seven ores, (omitting No. 61,) will give, on an average, 41.43 of iron. No. 60, the "grey block ore," is a carbonate of iron, containing 28.20 per cent. of iron, and 46.40 per cent. of carbonate of lime; the rest are essentially hydrated oxydes. See Nos. 62 to 68 inclusive, of Dr. Peter's Report, for analyses of two limestones used as a flux, three kinds of furnace slag, and two varieties of pig-iron.

The "main block ore," No. 54, is ten to twelve inches thick, resting on an impure ("bastard") limestone, with some six inches of shale intervening.

The "little block ore," No. 55, overlies the "main block ore," with a shaly parting of one and a half to three feet; over this lies the "kidney ore," No. 56; grey, yellow, and black shales form the matrix of these ores; the stripping required to be removed before reaching the ores, varies from six to twelve feet. There is a "little block ore," associated with shale, lying near the bed of little Sandy river, two to three inches in thickness. This ore is, however, not at present used.

Eight to twelve feet of freestone, suitable for building purposes, lies twenty to thirty feet under the "main block ore." One and a half miles east from the furnace is an eighteen-inch coal, that appears to occupy a position higher than the six-inch coal, or the above described ore beds.

The limestone used as a flux lies low in the hills, near the level of the branches. From thirty-five to forty, or sometimes fifty pounds of this limestone are added to half a charge of eight hundred and seventy pounds of roasted ore.

The cost of delivering the ore at the works is $2 25 to $3 per ton.

The Buffalo hot-air-blast furnace, L. Holister & Co., runs about eight tons, on an average, in twenty-four hours.

In the hills adjacent to the Raccoon furnace there are two beds of coal: a thin coal of two feet, including shale, or eight to ten inches of pure coal, near the level of Raccoon creek, and a thirty-four-inch coal, which is three hundred feet up in the hills, one mile north-east of the furnace, and probably about two hundred and eighty feet above the lower coal. The upper coal has a clay parting of a few inches at the entrance, but increases to a foot or a foot and a half—the upper member being twenty-four inches, the lower nine inches to one foot, making from thirty-one to thirty-four inches of coal in all.

Four varieties of ore have been analyzed, from the Raccoon ore banks, (Nos. 80, 81, 82, and 83, of Dr. Peter's Report.) They are all hydrated oxydes, yielding, on an average, fifty-two per cent. of iron: the richest, No. 83, the "main upper kidney ore," lying high up in the hills, yielding as high as 56.44 of iron. No. 80, lying two-thirds up the hill, is improperly called a "limestone ore," as it contains only 0.49 of carbonate of lime. The dark brown, "red block ore," No. 81, containing 53.36 of iron, is not only a rich ore, but, as Dr. Peter suggests, might be used as a pigment. For the chemical analyses of the limestone used as a flux, furnace slags, varieties of pig-iron, and coal, see Dr. Peter's Report, Nos. 84 to 90 inclusive.

The block ore will average about eleven inches in thickness. There is a lower "block ore," of about six inches, which lies about eighty feet up in the hills.

About one-tenth of limestone is used to flux these ores, i. e., about one hundred pounds of limestone to half a charge of one thousand pounds of roasted ore. The limestone is obtained at Old Town creek, from a bed fifteen feet thick, and probably belongs to the sub-carboniferous group.

The Raccoon hot-air-blast furnace, Holister, McGrew & Co., runs, on an average, about eight tons of iron in twenty-four hours; sometimes eleven tons are run out in twenty-four hours. The cost of delivering the ore is from $2 50 to $3 per ton. Two hundred bushels of charcoal are consumed in making a ton of iron.

In passing up the valley of the left branch of Old Town creek, in going from the Raccoon to the Laurel furnace, the shale overlying the lower coal is seen, and a schistose sandstone twenty-five to thirty feet above it.

The lower ore bed of the Laurel furnace lies from ninety-five to one hundred feet above the forks of Old Town creek. The principal ore beds lie, however, from twenty-five to forty feet below the top of the ridges, intermixed with black, yellow, and grey shales. The "main block ore" is some fourteen inches thick, and has been worked to some extent by drifts. It is mostly of deep dark brown or red color, like No. 81, passing downwards into a ferruginous limestone, and upwards into varieties of kidney ore, some of which has a nucleus of light grey carbonate of iron? The "main Baker ore" runs fron six to sixteen inches in thickness, and will average ten inches. It underlies the kidney ore, with shale intervening. The "Ward ore" varies in thickness from four to ten inches, and will average eight inches.

Locally the "Baker ore" runs into what is called a "limestone ore," or even into an impure limestone three feet in thickness. The stripping required to reach these ores is from six to twelve feet. The "kidney ore" from the "Birch bank" has much sulphate of lime disseminated through the fissures of the ore. This ingredient would, I believe, be injurious to the successful working of the furnace; because the sulphur contained in such ore would not be driven off by roasting, but, remaining in the state of anhydrous sulphate in the roasted ore, when this is subject to the high reducing temperature of the furnace the sulphuric acid is probably decomposed, and the sulphur set free may combine, in part at least, with the iron.

Indeed, I perceived at one of the "run-outs," made whilst I was there, a strong odor of sulphurous acid, which gives proof of the presence of sulphur; also, a dark crust forming rapidly on the surface of the molten iron before the temperature was reduced to the chilling point, which is also usually regarded by foundry-men as evidence of the presence of sulphur; but, as a similar appearance takes place with an excess of carbon, it would be unsafe to decide the point from this phenomenon alone. However, I believe that the iron which the furnace was producing at that time was of that quality of high white metal which is apt to be produced by excess of sulphur. The only certain method, however, to arrive at positive conclusions in regard to this matter, would be to make an accurate analysis of the pig metal produced from this ore. Time has not permitted the analysis of the ores smelted, nor of the products of the Laurel furnace; but, if the geological survey is continued, these will be undertaken early next season.

Just below the Laurel furnace forty to fifty feet of sandstone forms a low escarpment, that runs a considerable distance up Old Town creek. This is probably the lowest massive sandstone that reposes almost immediately on the sub-carboniferous limestone of that stream and Tygert; though no pebbles are seen in it at this place, it no doubt occupies the place of the lowest conglomerate. At the Junior furnace, in Scioto county, Ohio, a few inches of coal underlies this sandstone; whether it does so on the Kentucky side, in Greenup county, I am unable, at present, to say.

Some of the ore banks of the Kenton furnace lie near the works, others about two miles off. Two kinds of ore are principally smelted at this establishment—a "block ore," which runs in a regular band of six to eight inches thick, at an elevation of about two hundred and ninety feet in the hills; this usually forms two-thirds of the furnace burthen; the other third is a "limestone ore," which is situated about sixty or seventy feet lower, and ranging from eight inches to three feet in thickness, averaging about eighteen inches. A little "kidney ore" overlies the "block ore." The stripping required for the top hill ore is from two to nine feet. The "block and kidney ores" can be delivered at a cost of $2 per ton; the "limestone ore" at $2 50 per ton. At one place a drift has been carried into the hill after the limestone ore, between the sandstone and limestone; this must be one of the lowest stratified ores in the basin. The iron produced from the ores smelted at the Kenton furnace is tough, and held in esteem at the rolling mills; it is also good for making axes, boiler iron, and car wheels. Forty pounds of limestone are used for half a charge of seven hundred pounds of roasted ore.

The cold-blast Kenton furnace, J. Warren & Co., runs nine tons of iron in twenty-four hours.

The ores smelted at the New Hampshire furnace occupy nearly the same geological position as those of the Kenton, and are the lowest *stratified* ore beds of the eastern coal field. The former have some local peculiarities, especially the so-called "speckled ore" of the New Hampshire furnace. This ore lies in connection with a local bed of chert that intervenes between the sub-carboniferous limestone and the overlying sandstone, replaced locally by limestone ore. From the chemical analysis made of one variety, it contains a very large quantity of alumina and soda, and a considerable amount of potash and phosphoric acid; the latter is probably derived from the organic remains found in this ore.

| | | | |
|---|---|---|---|
| Moisture, | 5.110 | | |
| Insoluble silicates, | 49.940 | Silica, | 35.4 |
| | | Alumina, tinged with iron, | 14.0 |
| | | Lime, | 0.3 |
| | | Magnesia, | 0.2 |
| | | | 49.9 |
| Peroxide of iron, | 20.000 | 17.92 iron. | |
| Protoxide of iron, | 5.040 | | |
| Alumina, | 13.500 | | |
| Magnesia, | 0.363 | | |
| Soda, | 4.502 | | |
| Potash, | 0.885 | | |
| Phosphoric acid, | 0.636 | | |
| Loss, | 0.024 | | |
| | 100.000 | | |

The five other ores, (Nos. 103 to 107 inclusive, of Dr. Peter's Report,) are also hydrated oxydes. One of these, No. 104, is, in reality, not an ore, as it only contains 9.27 of iron. Leaving this one out the other four will average thirty-seven per cent. of iron. The block ores, Nos. 103 and 104, are found near the tops of the hills, where they are obtained by stripping from three to twelve feet of argillaceous earth. The limestone ore lies locally between the sandstone and limestone; it is very variable in thickness, ranging from a few inches to three or even four feet, and is, occasionally, absent. The limestone and limestone ore decline, and the former thins out from the head of Buffalo to White oak.

The hearth-stones employed at the New Hampshire furnace are a greenish micaceous sandstone, which seems to stand the fire much better than might be anticipated from its external aspect, judging from the indurated and unfused appearance of the rock which had been subject to the furnace heat for two months. Analysis No. 115, of Dr. Peter's Report, is of this rock before being subjected to the furnace heat, and No. 116 after two months exposure; from these analyses it appears that it had lost 2.4 per cent. of oxyde of iron and alumina, 0.14 per cent. of carbonate of lime, 0.010 of potash, and .018 of soda.

Two limestones, three furnace slags, and two varieties of pig-iron have been analyzed from this furnace, (see Dr. Peter's Report, from Nos. 108 to 114 inclusive.)

The New Hampshire hot-air-blast furnace, Conway, White & Co., makes about eight tons in twenty-four hours.

These sixteen furnaces are capable of producing thirty-five to forty thousand tons annually, if in full blast, except during the time necessary to renew the hearth, and for other repairs; I believe, however, at present, they will not run more than thirty weeks during the year; many, it is true, remain in blast nine or ten months in the year, but there are several that are not in operation more than five or six months in the year. The average weekly run may be put at fifty tons, hence fifteen hundred tons per annum may be taken as an average production for each furnace; this gives, for the whole, twenty-four thousand tons, which is as near their present production as I have the data for estimating, and is, probably, rather over than under the actual amount.

Professor Wilson, of the British Commission to the New York Exhibition on the Iron Industry of the United States, estimates the Ohio, Cumberland, and Tennessee iron furnaces, producing iron from charcoal, at one hundred and fifty thousand tons per annum. In which estimate, I believe, he intended to include the furnaces of Greenup and Carter counties; but, even supposing that he did not, and that we add their production to this estimate, it will give one hundred and seventy-four thousand tons. Yet how small a production is this compared with the consumption in the Western States! which amounts at this time, or very soon will, to one million tons.

The principal bar, at present, to a rapid increase in the iron production of this region, is the great cost of charcoal.

When these ores of Greenup and Carter counties come to be smelted with coal, as they undoubtedly must before very long, the amount of iron which they are capable of supplying is immense. We have seen, from the facts collected simply by a rapid reconnoissance of the country, that from five to eight beds can be found above the drainage of the country, in ridges three hundred feet high, which will often average eighteen inches in thickness; and the geological position of the ore is such that these beds may be followed entirely through the hill in comformable stratification with the associated beds of coal. We have seen, moreover, from the chemical analyses of these ores, that they will average, at a very moderate estimate, one third the weight of iron from the raw ore. Taking the united thickness of the different beds in a single hill at five feet, and the specific gravity of the ore at 3., then each acre of land, underlaid by these ores, is capable of yielding from six to seven thousand tons of iron, which, in the form of pig-iron, may be estimated to be worth at least $180,000. The same hills usually contain beds of coal, which may be estimated to have a united thickness of from five to six feet, which, after deducting for waste and slack, would yield eight thousand to ten thousand tons of coal, worth from $16,000 to $20,000.

How important are such developements as these to any country, but more especially to a region whose agricultural capabilities are but limited!

On the waters of Tygert creek, in Carter county, good ore of the class of hydrated oxide occurs, yielding 50.07 per cent. of iron. (See No. 12 of Dr. Peter's Report.) This ore occupies a different geological position from the regularly stratified ores just described, belonging to the Coal Measures; since it is found in connection with the sub-carboniferous limestone, very much after the manner of the ores of the Cumberland and Tennessee rivers, in the western part of Kentucky, which have already been treated of in general terms in first chapter of this Report.

So far as my examinations have yet been carried, it seems to be most abundant in the dividing ridge between Tygert and Kinniconick, near the confines of Lewis county, near Mr. Macleas, where the belt of the sub-carboniferous limestone is wider, and better developed, than it is in Greenup county. This belt of sub-carboniferous limestone widens in its southern range; near the heads of the Buffalo branch of Tygert creek it attains its greatest elevation in Carter county; bearing thence to the south-west to the waters of Triplett creek, in Fleming county. I have not yet had an opportunity of following it in that direction beyond the confines of Carter county.

In Carter county, on the waters of Stinson creek, a cannel coal, of somewhat analogous composition to the Breckinridge cannel coal, crops out towards the summits of the ridges, two and a half miles from Grayson, and within a mile or a mile and a half from the Big Sandy and Lexington railroad. It is from twenty to twenty-two inches in thickness. Its composition is,

| | | |
|---|---|---|
| Specific gravity, | 1.216 | |
| Total volatile matter, | | 59.0 |
| Coke, (does not alter in form in coking,) | | 41.0 |
| | | 100.0 |
| Moisture, | 2.0 | |
| Volatile combustible matter, | 57.0 | |
| Fixed carbon, | 34.5 | |
| Ashes, (flesh colored,) | 6.5 | |
| | 100.0 | |

A similar coal out-crops on Barrett's creek, six miles from Grayson, and within a few hundred yards of the Big Sandy and Lexington railroad. This is probably a lower bed, as it occurs within a short distance of the range of sub-carboniferous limestone. This bed is covered by four feet of grey silicious shale, underlying a massive sandstone, over which is a ferruginous shale, containing a bed of good kidney iron ore.

When the detailed survey of Carter and Greenup counties comes to be made, it is probable that two, if not three, beds of cannel coal will be discovered—one near the base of the Coal Measures, and one in connection with higher ore beds.

### COAL MEASURES

*Of Lawrence, Johnson, Floyd, Pike, Letcher, Perry, Breathitt, Harlan, Clay, Knox, Whitley, and part of Owsley, Laurel, Pulaski, Wayne, and Clinton counties.*

In the first Chapter I have already treated, at some length, of the geological relations and chemical composition of some of these coals, especially in Lawrence and Floyd counties.

At the Forks of Big Sandy, behind the town of Louisa, a two-foot coal lies one hundred and seventeen feet above low water. There is said to be a twenty-inch coal about thirty feet lower, and another two-foot coal near the level of the river. These two last coals I have, as yet, had no opportunity of examining.

Four miles below the Forks of Big Sandy, symptoms of salt water appear by saline oozings, licks, and sudden disengagements of gas. At one point, near the Kane farm, now owned by Mr. Wallace, some borings have been put down, to test the practicability of obtaining strong salt water; at one hundred and forty feet a brine was struck; at one hundred and sixty feet it was obtained of sufficient strength to afford salt at thirty cents per bushel, but not being able to compete with Kanawha salt at twenty-five cents per bushel, works were never erected. If the carboniferous rocks form a synclinal fold here, or an impervious fault runs along the valley of Big Sandy, *deep* borings for salt might reach a still stronger brine. This can only be determined by a minute survey of the formations of Lawrence county.

In the vicinity of the Falls of Blain I examined a locality, on land owned by Mr. Wallace, where some ore was discovered, (No. 11 of Dr. Peter's Report.) It can hardly be considered sufficiently rich to work by itself, as it only contains 19.24 per cent. of iron, but since it contains 51.35 per cent. of carbonate of lime, it might be worked advantageously in connection with other ores destitute of lime, and containing forty or fifty per cent. of silica and insoluble silicates, probably without the necessity of the addition of any other limestone as a flux than that which it contains. This ore, most likely, occupies the same geological position as the "limestone ore" that supplies the Sandy furnace.

A coal, some four feet in thickness, is said to occur in the bed of Blain, below the falls; also two beds, each two feet to two and a half feet in thickness, on Two-mile creek, near Big Sandy, and a four-foot bed, below the mouth of Fuller's branch, about one hundred to one hundred and twenty feet above low water. These localities have, however, as yet, not been examined.

On the Tug fork of Big Sandy, five miles above its mouth, a bed of coal lies forty feet above low water, which measures from three feet to three and a half feet, with a six-inch shale parting, six inches from the bottom of the bed—this coal is No. 181 of the State collection. Its composition is as follows:

| | | |
|---|---|---|
| Specific gravity, | 1.313 | |
| Total volatile matter, | | 40.0 |
| Coke, (lamellar in structure,) | | 60.0 |
| | | 100.0 |
| Moisture, | 3.0 | |
| Volatile combustible matter, | 37.0 | |
| Fixed carbon in coke, | 50.0 | |
| Ashes, (whitish grey,) | 10.0 | |
| | 100.0 | |

A few inches of the upper part of this coal has the close-texture and fracture of cannel coal; the roof is sandstone.

Up the Vincent branch of the Tug fork an out-crop of coal, of four feet four inches, including four to six inches of a clay parting, at one foot eight inches from the top, rests on sandstone, with a covering of schistose, grey and dark argillaceous shale. It has a local northerly dip of several degrees, which does not, however, appear to prevail for any great distance. This is probably a superior bed to the preceding. Its composition is:

| | | |
|---|---|---|
| Specific gravity, | 1.260 | |
| Total volatile matter, | | 45.5 |
| Coke, (lamellar,) | | 54.5 |
| | | 100.0 |
| Moisture, | 2.5 | |
| Volatile combustible matter, | 43.0 | |
| Fixed carbon in coke, | 51.5 | |
| Ashes, (yellowish-white,) | 3.0 | |
| | 100.0 | |

On Three-mile creek the York bed of coal is four feet, with a clay parting of one foot five inches, near the top of the bed. Just on the opposite side of the ravine, hardly twenty steps apart, and almost on the same level, two feet four inches of coal appear under sandstone, with one foot four inches of interlaminations of shale and clay partings under the main coal, which together make three feet eight inches. It is hardly possible that two coals, lying so close to each other, and different in their relations, can be the same bed. It is more probable that a slip or dislocation of the strata has brought here two distinct beds in apposition.

I inspected also a bed of compact slaty cannel coal, on Three-Mile creek, similar to the Crawford coal, near Grayson, in Carter county; it seems, however, to run into bituminous coal, where the bed disappears under the water of the branch. A little lower down, on the same creek, three feet three inches of coal occurs, with a six-inch clay parting near the top. This may be an inferior bed.

On a branch of Three-mile creek, three-quarters of a mile north-east of Big Sandy, I examined the out-crop of a very thick coal, apparently seven feet in thickness, with two clay partings of about one foot, leaving from five and a half to six feet of good coal. This is, very probably, the equivalent of the main Mellensburg Peach Orchard coal. This bed has ledges of sandstone both above and below, with a few feet of shale immediately over the coal, intermixed with some decomposed coal in the upper part. There may be, therefore, three members in all to make up this bed. The hills on Three-mile creek seem to be about five hundred feet high, the strata having an easterly dip.

The main coal of Big Sandy, in Lawrence county, seems to be very variable in character and thickness. At the entrance on the southeast side of Big Sandy, the measurement gave,

| | *Feet.* | *Inches.* |
|---|---|---|
| Shale, | | 6 |
| Coal, | 3 | |
| Argillaceous shale, | 2 | |
| Coal, | | 8 |
| | 6 | 2 |

At the terminus of the tunnel, on the other side of the ridge, it gave,

| | *Feet.* | *Inches.* |
|---|---|---|
| Roof—2 to 3 feet of black and grey argillaceous bituminous shale. | | |
| Coal, | 1 | 5 |
| Black bituminous argillaceous shale, | | 10 |
| Coal, | 1 | 6 |
| Black shale, | | 4 |
| Coal, (in some places 3 feet,) | 2 | |
| Black shale or "boney coal," | | 6 |
| Coal, | 1 | 5 |
| | 8 | 0 |

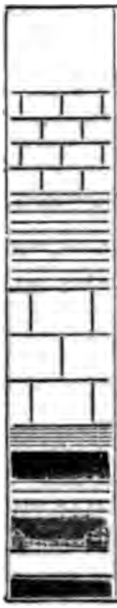
Here the coal is divided by shale into four members, making from six feet four inches to seven feet four inches of coal, and lies about two hundred feet, at this point, above the bed of Big Sandy; the total height of the ridge being six hundred feet. Two thin coals occur in the same hill—one at thirty feet, some eighteen inches thick; another at seventy-five to eighty feet, of a few inches. As yet no other workable coals have been discovered in these hills. At five hundred and seventy to five hundred and eighty feet, or three hundred and seventy-seven feet above the coal, there is a bed of kidney ore, said to be eight to ten inches thick.

The valley of Big Sandy, at this point, seems to flow in an obscure anticlinal fold—the coal having a very slight dip either way from the river; at least where it has been opened this appears to be the case.

In the bed of Big Sandy, at the mouth of Contrary creek, there is some coal overlaid by shales, which include segregations of carbonate of iron and carbonate of lime.

An interesting question remains to be solved by the detailed geological survey of Lawrence county, i. e., whether the two main Gavet coals, lying at one hundred and sixty-five feet and two hundred and twenty feet above Big Sandy, come together at Mellensburg, and united, form the main coal at that place.

Near the line between Floyd and Pike counties, at the Industry mines of the Big Sandy Coal and Manufacturing Company, owned by Aaron & Bigs, the main coal consists of three members, and lies one hundred and twenty-five above Big Sandy, covered by sandstone. ("Post" of the Miners.) The united thickness of the three members of coal being from seven and a half feet to eight feet. The section presents itself thus:



| Feet. | Inches. | |
|---|---|---|
| | | Flag-stones. |
| | | Grey argillaceons shale. |
| 14 | | Sandstone, ("Post.") |
| | 4 | Black shale, 2 to 4 inches. |
| 2 | 6 | Coal, 2 feet 6 inches to 3 feet. |
| 2 | 8 | Shale, 2 feet 8 inches to 3 feet. |
| 3 | 8 | |
| | 4 | Fire-clay, 4 inches. |
| | 10 | Coal, 4 to 10 inches. |

The lower member, which averages three feet ten inches, is the best coal, and commands nearly double the price of the upper member, which is two feet ten inches.

An analysis of the lower main member yielded,

| | |
|---|---|
| Total volatile matter, - - - - - - - - - - - | 35.2 |
| Coke, (good, compact, does not swell up,) - - - - - - | 64.8 |
| | 100.0 |

| | |
|---|---|
| Moisture, | 3.0 |
| Volatile combustible matter, | 32.2 |
| Fixed carbon in coke, | 63.8 |
| Ashes, | 1.0 |
| | 100.0 |

The upper member yielded,

| | |
|---|---|
| Total volatile matter, | 39.0 |
| Coke, (swells up slightly in coking,) | 61.0 |
| | 100.0 |

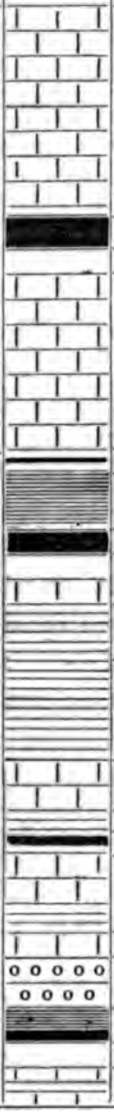
| | |
|---|---|
| Moisture, | 2.0 |
| Volatile combustible matter, | 37.0 |
| Fixed carbon in coke, | 59.0 |
| Ashes, (dirty white,) | 2.0 |
| | 100.0 |

Three or four miles below this locality coal crops out about thirty or forty feet above the bed of Big Sandy, under ledges of schistose sandstone.

A mile and a half or two miles above Prestonsburg two beds of coal appear, one high up in the hills, with calcareous septaria about thirty feet below it, fallen out of shaly rocks.

In the vicinity of Prestonsburg some four or five different beds of coal overlie each other in the hills. The main bed is situated seventy or eighty feet above the bed of Big Sandy; one about forty or fifty feet lower in the hills; one sixty feet higher; one one hundred and fifty feet above the main coal; one at low water, and a fifth below the bed of the river.

At the Northern Kentucky mines the main bed varies in thickness from three feet ten or eleven inches to three feet three inches, and will average about four feet, with a clay parting of half an inch ten inches from the top of the coal. Over the coal is half an inch of black shale, and then flag-stones passing into thicker beds of freestone; the floor is one foot of fire-clay. The clay parting increases in running into the hill, to eight inches, thinning down stream, towards the north, and thickening up stream, towards the south. It is a good hard coal, free from pyritiferous impurities, and stands exposure and handling well, with a good roof of flag-stones. The half inch of black shale intervening is full of fossil plants. For about forty yards to the west the bed lies tolerable level, it then dips half an inch to the yard. A section near the drift gave as follows:



| Feet. | Feet. | Inches. | |
|---|---|---|---|
| 89 | | | Sandstones and |
| | 20 | ½ | Flagstones, with one half inch shale over |
| | 4 | | Main coal, with clay parting. |
| 69 | | | Fire clay. |
| | 17 | | Sandstone. |
| 51½ | | 2 | Two inches of coal. |
| | 4 | 6 | Black shale. |
| | 3 | | Coal. |
| | | | Fire-clay and sandstone. |
| | 5 | | Shale. |
| | 10 | | Grey indurated shale. |
| 30 | 3 | | Sandstone and |
| | | 9 | Black shale. |
| | | 6 | Coal, six inches. |
| | 3 | | Sandstone and silicious shale. |
| | | 6 | Sandstone. |
| | 3 | | Grey shale, with carbonate of iron. |
| 5 | | 9 | Black bituminous shale, with splint coal. |
| | 1 | 6 | |
| 0 | 1 | 6 | Grey metal, at low water of Big Sandy. |

A coal was struck, in boring for salt, below the bed of the river, the distance out is not known.

Though the strata dip locally for a short distance south, a more prevalent dip in this region is north 30° west.

The general arrangements of the different beds of coal on this part of Big Sandy, so far ascertained, appears to be,

| | *Ft.* | *Inch.* | *Ft.* | *Inch.* |
|---|---|---|---|---|
| A top hill coal, (No. 6.) | | | | |
| Space, undetermined. | | | | |
| Coal, (No. 5,) 230 feet up in the hills, | 1 | 6 | | |
| Space, | | | 100 | |
| Coal (No. 4,) structure of cannel coal, 2 feet 8 inches to | 3 | 4 | | |
| Space, | | | 30 | |
| Coal, (No. 3,) 77 feet up in the hills, | 4 | | | |
| Space, | | | 25 | 6 |
| Two-inch coal, 51½ feet up, | 0 | 2 | | |
| Space, | | | 7 | 6 |
| Coal, (No. 2,) 44 feet up, | 3 | | | |
| Space, | | | 42 | |
| Six-inch coal, (No. 1,) 2 feet above low water of Big Sandy, | 0 | 6 | | |

The bed that crops out just opposite Prestonsburg, at ninety-eight feet above the river, is of a compact, close-texture, approaching cannel coal, different in appearance, fracture, composition, and roof from the main bed, and being thirty feet higher above the river than it, both above and below Prestonsburg, I think it must be a distinct bed. Two miles above Prestonsburg, on the East branch of Big Sandy, I examined a coal bed owned by Col. Martin, sixty feet above the river. It consists of two members, separated by a clay parting of ten inches, there being from three feet ten inches to four feet of excellent coal, as will be seen by the following analysis:

| | |
|---|---|
| Total volatile matter, | 38.0 |
| Coke, (but little changed in form,) | 62.0 |
| | 100.0 |

| | |
|---|---|
| Moisture, | 3.5 |
| Volatile combustible matter, | 34.5 |
| Fixed carbon in coke, | 61.0 |
| Ashes, (light flesh-colored,) | 1.0 |
| | 100.0 |

This is a remarkably pure coal; indeed the main Prestonsburg bed, generally, is one of the very best coals which has yet been analyzed for manufacturing purposes. The property which it possesses of being little changed in form shows that it does not contain much bitumen, a material which acts injuriously in a coal used for smelting iron.

Half a mile below town coal No. 4, of the Prestonsburg section, is seen, ninety-three feet above the river, where it is three feet four inches.

At the mouth of Abbott's creek, in Floyd county, a coal has been opened, thirty-four feet above Big Sandy, three feet eight inches in average thickness. It has no clay parting; the roof is a kind of flagstone similar to that over the coal opposite Prestonsburg, running into twenty feet of schistose sandstone in the hill above; over that fifty feet of solid sandstone.

Borings have been made below Big Sandy, in the neighborhood of Prestonsburg, for salt water without much success. It is probable, from the general knowledge obtained of the formation there, by the geological reconnoissance of the past season, that the borings would have to be carried to a great depth to reach a productive brine, as the Prestonsburg series appears to lie high in the Coal Measures.

Near the line between Floyd and Johnson counties there is an outcrop of coal under schistose sandstone, very possibly the equivalent of the Abbot bed; there are also out-crops of other coals lying higher in the section. Some iron ore was also observed in some of the ridges passed over between the mouth of Abbott's creek and the county line. Between this and Paintsville the hills decline in height, apparently from a sinking of the formations down stream, towards the north.

Below the town of Paintsville, on the banks of Paint creek, twenty-six feet of shale is exposed, containing some carbonate of iron; the lower part of the shale is highly bituminous, running almost into coal; and at twenty-three and a half feet above the foot of the dam one foot of coal lies in the shale, not far under a ledge of sandstone of two feet, passing upwards into schistose sandstone.

In the ridge north of Paintsville there is a heavy bed of dark shale, with carbonate of the protoxide of iron. At about one hundred and sixty feet above Paint lick, lower down in the hill, there is supposed to be a regular band of carbonate of iron, six inches thick, associated with a few inches of coal.

A bed of coal of ten inches probably lies in the first bench of this ridge, and another of eighteen inches in the second bench, above a heavy sandstone.

On the Wheeler branch of Paint creek, in Johnson county, one to one and a fourth miles north-west of Paintsville, a four-foot coal comes out under flag-stones, reposing on fire-clay, and dipping at an angle of 2° south 80° east. Its elevation above Paint creek is about one hundred and ninety-five feet. This coal has no visible clay parting.

Four to four and a half miles up Paint creek cliffs of sandstone of fifty to sixty feet extend down to the water level.

Ten miles from Paintsville, on the Oil Spring branch, oozings of petroleum float on the water, where it is said two hands may sometimes collect a barrel in day.

On the Oil Spring fork of Paint creek the rocks are mostly shaly. In the gap that leads from that creek to State road creek a bed of coal, from fourteen to eighteen inches thick, crops out; and a thicker coal has been reached, under a covering of soil and sub-soil, on an adjacent branch, not far from the gap.

About three miles from Licking station I observed a calcareous rock in the bed of State road creek, which may be of value in a country where limestone is difficult to obtain, since, in many parts of the country, the settlers have been obliged to go forty and fifty miles, into Estill county, after limestone. The rocks are mostly schistose sandstone and beds of grey shale, with occasionally a bed of thicker bedded sandstone.

Near the Licking station there are thick beds of black shale, fifteen to twenty feet in thickness, including masses of carbonate of lime and carbonate of iron. Large segregations of the latter also occur in the form of septaria, in strata resting on thin bedded sandstone. About one mile and a half down this branch I observed a bed of hard limestone, nine inches in thickness, and a mile further two beds of coal, one a foot, the other six inches, between beds of sandstone, lying twenty-three feet above the first. Six to ten inches of coal crop out on the Middle fork of Licking. A thin bed, probably the equivalent of some of the above beds, occurs three or four miles down the Hunting branch.

Calcareous septaria are of frequent occurrence in the hills of this part of Morgan county, some of which, on the waters of Quick-sand, would weigh tons; some of these may, probably, be suitable for manufacturing into hydraulic cement. Thin seams of coal were also seen on Quick-sand, one of which, eighteen inches in thickness, is exposed in a good section, four miles above Jackson, in Breathitt county.

Borings have been made for salt on the Licking, below Licking station, and some salt obtained, but it was never worked to any extent. A productive brine is said to have been obtained, however, on the North fork of the Kentucky river, nine or ten miles above Jackson. Until a more detailed examination is made, so as to determine where the system of synclinal folds of the rocks form favorable reservoirs for salt, it would be premature to pronounce upon the prospects on this part of the North fork of Kentucky river, for productive and durable brines; if the location should prove to be favorable it would be a very great advantage to the country, as salt is one dollar per bushel in this part of the State.

Lower down, on the North fork, a workable coal, four feet in thickness, bassets towards the base of the hills, with another coal above it, the thickness of which has not been determined. The main coal has been entered in several places near the river, above and below Jackson, and an extensive business is here carried on in the coal trade, which supplies most of the ready cash circulating in the country. The belt of the muriatiferous rocks of the Coal Measures promises to be wide in this part of Kentucky, judging from the indications presented during the reconnoissance of this part of the State.

Shaly rocks are also the prevalent stratification in the hills bordering on the North fork of the Kentucky river, in the central portion of Breathitt county; though there are some massive sandstones near the mouth of Quick-sand. Some carbonate of iron is interspersed in the shales, but, as yet, I have not observed any very rich deposits of this ore.

At the junction of Lost and Troublesome creeks, salt water has been obtained at a depth of four hundred and twenty feet, sufficiently strong to make a bushel of salt from one hundred gallons of the brine; but I have not yet had an opportunity of ascertaining its geological relations; nor yet that of a bed of cannel coal reported high in the hills opposite the mouth of Troublesome creek, four feet in thickness. An analysis has, however, been made of a sample of this coal which I procured at Jackson, which yielded the following result:

| | | |
|---|---|---|
| Total volatile matter, | | 58.0 |
| Coke, (rather diminished in size,) | | 42.0 |
| | | 100.0 |
| Moisture, | 1.0 | |
| Volatile combustible matter, | 57.0 | |
| Fixed carbon in coke, | 36.5 | |
| Ashes, (grey,) | 5.5 | |
| | 100.0 | |

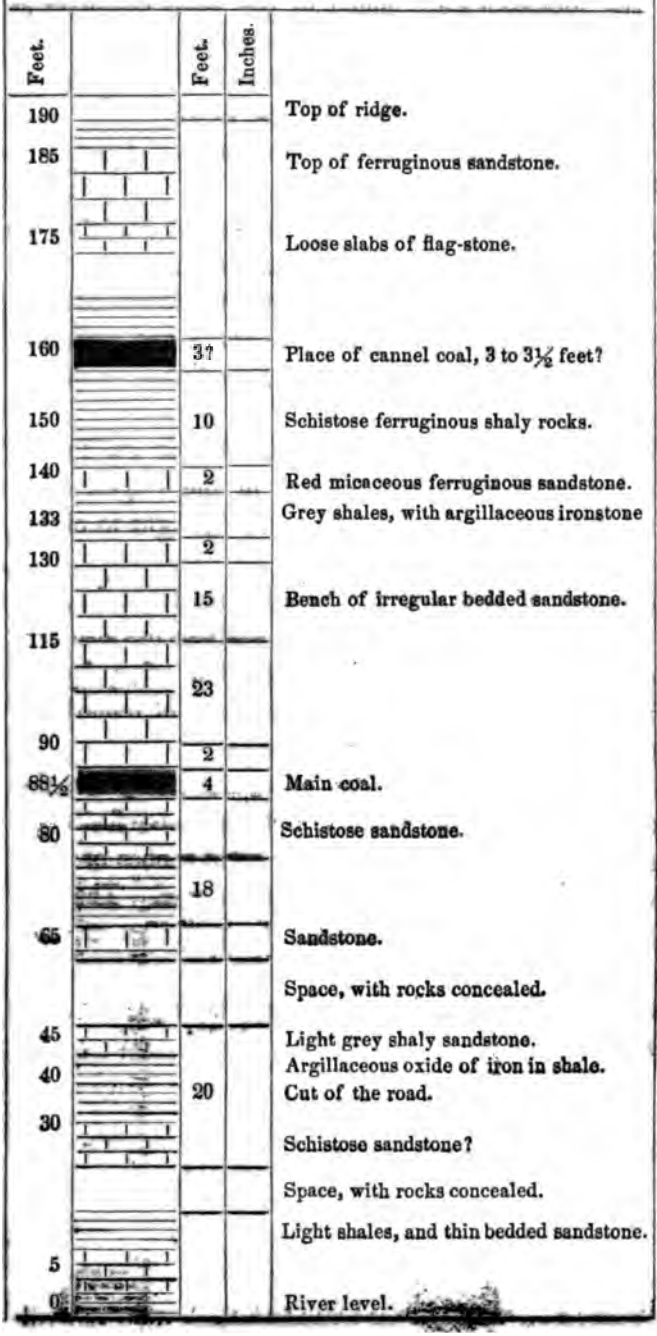
It is very probable that this might be a profitable coal to work for its oily and paraffin products; and it would be advisable that a sufficient quantity of it be forwarded to the Chemical Assistant, Dr. Peter, at Lexington, for analysis of its proximate constituents and ultimate elements: say fifty pounds.

The bed of coal which Isaac Bach opened, three miles by land and four miles by water above Jackson, is thirty-eight inches thick. This bed lies lower in the hills than the main bed at Jackson, and may be a distinct bed.

At Jackson the main coal lies eighty-eight and a half feet above the North fork of the Kentucky river. It varies from three and a half to five feet in thickness, with a clay parting of from three to ten inches, one foot from the bottom of the coal. The roof is an argillaceous shale, fifteen to twenty feet in thickness.

The approximate section in Breathitt county, near Jackson, is as follows:

APPROXIMATE SECTION OF 190 FEET OF THE HILLS OF BREATHITT COUNTY.


Feet.
Feet.
Inches.
190
Top of ridge.
185
Top of ferruginous sandstone.
175
Loose slabs of flag-stone.
160
3?
Place of cannel coal, 3 to 3½ feet?
150
10
Schistose ferruginous shaly rocks.
140
2
Red micaceous ferruginous sandstone.
133
Grey shales, with argillaceous ironstone
130
2
15
Bench of irregular bedded sandstone.
115
23
90
2
88½
4
Main coal.
80
Schistose sandstone.
18
65
Sandstone.
Space, with rocks concealed.
45
Light grey shaly sandstone.
40
Argillaceous oxide of iron in shale.
20
Cut of the road.
30
Schistose sandstone?
Space, with rocks concealed.
Light shales, and thin bedded sandstone.
5
0
River level.

The main bed of coal is thickest one to two miles above Jackson, where it measures five feet with the clay parting, which is there nine to ten inches.

At J. South's drift the main coal lies one hundred and thirteen feet above the river, with ledges of sandstone at one hundred and thirty eight feet, and fifteen feet of shaly argillaceous sandstone. The sandstone ledges can be traced to one hundred and forty-five feet.—About two hundred feet above the river blocks of hornstone and chert lie strewed on the ridge—rocks which are by no means of common occurrence in the Coal Measures of the west. The dip of the rocks is south twenty degrees to thirty degrees east.

On Cane creek the formations are much of the same character as on the North fork of the Kentucky—shaly rocks predominating. On Lower Twin creek there is more sandstone near the bed of the creek. On the head waters of Cane creek, in the vicinity of the Twin Gap, there are several out-crops of thin coal; but none were noticed over eighteen inches thick.

Many years since some salt was made high up on the Middle fork of the Kentucky river, near its confluence with Cut-shin creek.

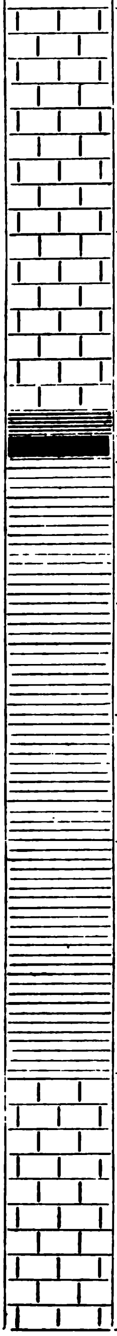
Some clay ironstone was observed in shales near C. Crawford's, in shales overlaid by grey ferruginous argillaceous shale, and underlaid by schistose argillaceous sandstone, with massive sandstone below the ferruginous shales.

At the Three forks of the Kentucky river some five or six beds of coal occur, between low water mark and the tops of the ridges. The main coal varies in height, above the river, from thirty-eight to eighty feet; its thickness being from three to four feet.

The chemical analysis of this coal for volatile matter, coke, and ashes, is given in the first chapter. An ultimate analysis has also been made of a specimen taken from the Todd & Crittenden mine, by Dr. Peter. (See his Report, No. 159.) The volatile part is remarkable for the large amount of oxygen which it contains.

The main coal, at the Todd & Crittenden mine, lies thirty-two feet above low water of the South fork, where it is from three feet eight inches to three feet ten inches thick, with six to eight inches of shale intervening between the coal and the solid sandstone roof. The floor is six inches to a foot of black shale, underlaid by pyritiferous sandstone.

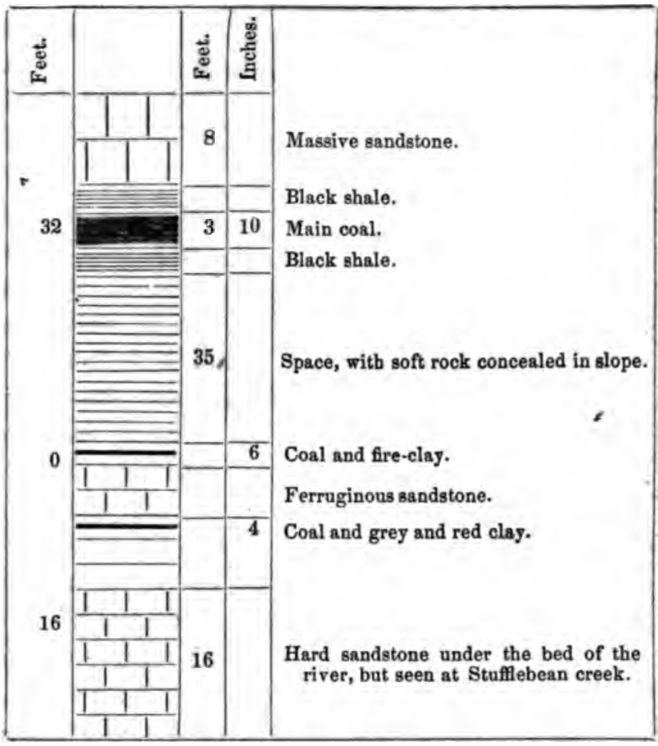
The approximate section, for two hundred and twenty-seven feet above low water, is as follows:



| Feet. | Feet. | Inches. | |
|---|---|---|---|
| 227 | 35 | | Yellow shaly sandstone. |
| 192 | 15 | | Schistose, ferruginous and carbonaceous sandstone. |
| 177 | 2 | | Black shale. |
| | 1 | 6 | Thin coal. |
| | 20 | | Grey argillaceous shale. |
| 155 | 17 | | Space, with shaly rocks concealed in slope. |
| 138 | 18 | | Blueish grey shale, with carbonate of iron. |
| 120 | 40 | | Space, with soft rocks concealed in slope |
| 80 | 37 | | Shaly sandstone, thin bedded. |
| 43 | | | |

It is probable that there is a bed of cannel coal lying to the east of south, higher than any of the coals here represented, which would make a fifth bed of coal where the lower bed is in two members, as on Stufflebean creek.

At John McGuire's entry the main coal lies sixty feet above Stufflebean creek, and about seventy feet above the Kentucky river. At the out-crop the coal measures three feet two inches, but increases in thickness in the hill to three feet six inches. It dips slightly into the hill for a short distance and then rises. The coal at this mine has a very distinct clearage, and comes out in fine


Feet.
Feet.
Inches.
8
Massive sandstone.
32
Black shale.
3
10
Main coal.
Black shale.
35
Space, with soft rock concealed in slope.
0
6
Coal and fire-clay.
Ferruginous sandstone.
4
Coal and grey and red clay.
16
16
Hard sandstone under the bed of the river, but seen at Stufflebean creek.

large blocks, weighing fifty to one hundred lbs.

At the upper drift the coal is only twenty feet above the creek. Here some bands of the carbonate of iron were obobserved in the shale of from 2 to 3 inches.—Beaty's drift is in the same hill as McGuire's, but on the opposite or south side.

The main coal is thinner on the North and Main fork of the Kentucky river, opposite Proctor, than on the South fork, but the former is rather freer from pyrites, and has a more uniform clearage, which favors its coming out in larger and finer blocks. The main coal has, for the most part, a jet black color and bright surface.

The floor of the main bed, at the foot of the shoals below Proctor, is one hundred feet above the river; the coal is three feet six inches thick, and is covered by black and grey shales.

At Dr. Dudley's entry the main coal lies ninety feet above the Kentucky river, and is three feet three inches thick, covered by shaly sandstone. The underlying bench of sandstone is forty feet above the river.

On Mick's branch a coal four feet three inches occurs, at an elevation of one hundred and twenty-five feet above the river. This may, possibly, be a different bed of coal, coming in over the shaly sandstone, that is in place near the same level at Proctor; or it may be, more probably, the main bed, which has increased in thickness, and occupies a higher position above the drainage of the country than at the other localities above cited, immediately on the river; since at Dr. Dudley's *lower* drift, one-quarter to one-half a mile above the mouth of Contrary creek, the main coal that has been discovered is from one hundred and fifty-five to one hundred and sixty feet above the river; and a few hundred yards below this grey compact limestone first shows itself, five to six feet above the waters of the Kentucky river, dipping at an angle of 15° south 80° west, and marking the junction of the Coal Measures with the sub-carboniferous limestone on the Kentucky river.

No thick coals have yet been discovered near Boonville. The coal which is principally used, at present, at that place, is an eighteen-inch bed, reached by stripping the soil and sub-soil at E. Isaacs', four miles from Boonville.

There is also some coal in the bed of Buck creek, near Ross'.

Five miles above Boonville, A. Gilbert has bored some three hundred feet for salt water, but not with success. A workable coal is reported one hundred feet down in the borings. The borings were never tubed to exclude fresh water; the failure to obtain a profitable brine may have arisen from overlooking this precaution. At any rate, the beds of sandstone on the South fork, near Gilbert's, have the cellular structure and character, and the shales about Boonville have those variegated colors often symptomatic of muriatiferous rocks.

At the mouth of Bull-skin a twenty-eight-inch coal occurs; and fragments of coal were found on Indian creek, and also detached masses of carbonate of iron.

The Burning Spring, of Clay county, is one of the remarkable geological phenomena of this section of the country. Through a pool of water in a narrow bottom a constant stream of gas escapes, in copious volumes. A lighted match suffices to set the gas on fire, which flashes instantaneously into numerous jets across the pool, continuing to burn until the force of the gas or a gust of wind blows it out. Judging from the color of the flame and the odor of the gas, it appears to be a mixture of heavy and light carburetted hydrogen, with some free or uncombined hydrogen.

The commotion in the water rendered it too turbid, without filtration, to test it satisfactorily for its saline constituents. Bi-carbonate of iron seems to be the principal constituent.

The gases must here reach the surface from some deep-seated source, through an extensive fissure of the rocks, concealed by the debris from the hills—perhaps from some bed of coal and iron ore exposed to surheated steam or other heat, by which decomposition is effected with evolution of these gases. Whatever their origin may be, the materials which supply the elements must be contained in the interior of the earth on a vast scale, since the "Burning Spring" has continued to evolve these gases with unremitting energy ever since the country was known to the first settlers. During half an hour which I continued to watch its action, I could not perceive any cessation or intermission.

Productive brines are obtained for many miles along Goose creek, in Clay county—particularly near the forks.

A brine of 6° was first reached at one hundred and twenty-one feet; at two hundred and forty feet it was 15°. For several years a brine of sufficient strength to be profitable was obtained at two hundred and ninety-three feet. The borings, after two or three years, were continued deeper, until an abundant brine was reached at five hundred and fifty-two feet, each gallon of which yielded, at first, nearly one and a quarter pounds of salt, and, at the present time, one bushel from eighty gallons.

From these muriatiferous strata, lying at this depth below the bed of Goose creek, seven different establishments produce annually about one hundred and thirty thousand bushels of salt. Borings have been carried, at one place, to about one thousand feet below the bed of Goose creek, without, however, any improvement in the strength or quantity of the salt water.

The rocks passed through in the borings are alternations of sandstone and shaly rocks. The strata which yield the best brine at five hundred to six hundred feet is a dark grey argillaceous or mud sandstone, with coaly particles disseminated, and containing the remains of fossil plants more or less carbonized. When the borings reach this rock the augur frequently slips into cavities, when the salt water gushes up, mixed with a black carbonaceous, muddy sediment, which, after a time subsides, and the water gradually becomes clear.

The main coal, which is worked for fuel to supply the salt works, is about thirty-two inches. At Col. Daniel Garrard's salt works it lies twenty-two feet above the bed of Goose creek. It rises to the north and sinks to the south, so that it is twelve feet below the bed of the creek at the forks; half a mile up the Collins fork it is forty-two feet below the creek, and two and a quarter miles ten feet lower. No other coal is reported in the borings on Goose creek; though I believe no strict account was kept of the materials passed through, which is to be regretted, since reliable information of all borings are a great assistance in developing the geology of the country Section No. 2 gives an approximate view of the stratification of the Goose creek country, as far as a mere reconnoissance has given a partial insight into its geology.

On Jack's creek, a branch of Red Bird, which comes in below the mouth of Phillips' creek, there is said to be a bed of coal some six feet in thickness; but I have not yet had an opportunity of examining this locality.

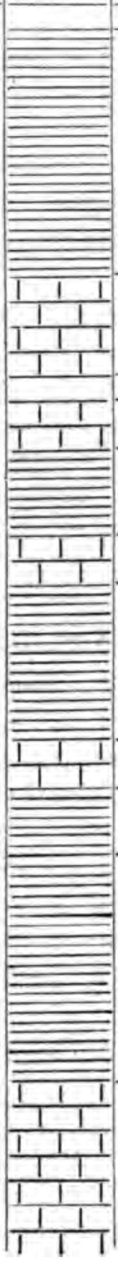
In the neighborhood of the Cumberland river, in Knox county, two or three miles above Barbourville, there are at least two, if not three, beds of coal; one, one foot three inches to one foot one inch, at an elevation of one hundred and thirty-eight feet above the Cumberland river; and one, two feet to two feet three inches, at one hundred and ninety-five feet. At an elevation of two hundred and twenty-five feet there are indications of another bed; of this latter I have not been able, as yet, to see a satisfactory out-crop. Near low water, and at ninety-three feet, it is possible other coals may be found.

The chemical examination of H. G. Miller's Mineral Spring, in Knox county, indicated, as the principal constituents, bi-carbonate of the protoxide of iron, bi-carbonate of lime and magnesia, a small quantity of chlorides—probably both chloride of sodium and chloride of magnesium; its medicinal properties are tonic, slightly aperient and deoxidizing.

Immediately over the spring is a thin bed of coal of six to ten inches, covered by about twenty inches of soft, reddish-brown sandstone, passing upwards into two to three feet of hard sandstone; below the spring are ferruginous red, grey, and dark shales, including thin bands of carbonate of iron.

The following section obtained on Linn-camp, near the confines of Knox and Laurel counties, presents very much the same materials that were observed in sections exposed between Barbourville and the Cumberland Ford.

### SECTION ON LINN-CAMP.

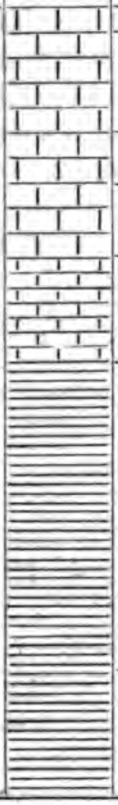


| Feet. | Feet. | Inches. | |
|---|---|---|---|
| | | | Top of the ridge. |
| 230 | | | |
| | 35 | | Soft argillaceous shale, with scaly oxide of iron. |
| 190 | | | Argillaceous and ferruginous shale. |
| 195 | | | |
| 185 | 10 | | Schistose soft sandstone. |
| 180 | 4 | | Top of bench of sandstone. |
| 165 | 11 | | |
| 160 | 5 | | Soft yellowish red sandstone. |
| | 20 | | Argillaceous and ferruginous shales. |
| 140 | 3 | | Sandstone. |
| 130 | 8 | | Ferruginous and ash-colored shales. |
| 129 | 29 | | Ash-colored shale, with verticle jointings, filled with argillaceous matter. |
| 100 | 19 | | Soft concretionary and jointed sandstone. |
| 81 | | | |

The lower portion of this section contains a considerable quantity of a variety of scaly yellow ochreous iron ore.

The cliffs along the Cumberland river, between the western confines of Knox county, about the "Narrows" and Thos. Faulkner's, are composed of thick beds of black shale, extending to the height of forty to fifty feet above the river, overlaid by thin-bedded sandstone, passing upwards into more solid ledges of the same. In some of the points of the ridges ferruginous shales crop out amongst the black shales, inclosing carbonate of iron. At an elevation of about one hundred and forty feet, and two hundred feet above the river, the same beds of coal can probably be found, which have already been cited as occurring two to three miles above Barbourville, at corresponding elevations.

SECTION ON LINN-CAMP.—Continued.



| Feet. | Feet. | Inches. | |
|---|---|---|---|
| 80 | 1 | | Soft pink sandstone. |
| 73 | 7 | | Schistose sandstone, with ferruginous veins. |
| 70 | 3 | | Soft argillaceous sandstone. |
| 65 | 5 | | Ferruginous and soft argillaceous sandstone. |
| 55 | 10 | | Thin-bedded and shaly sandstone. |
| | 45 | | Variegated red, brown, grey, and black shales, imbedding scaly argillaceous oxide of iron. |
| | 10 | | Black and grey shales. |
| 0 | | | Level of Linn-camp creek. |

The high range of hills in the southern part of Knox county, bearing southwest and northeast from the Shillalies to the Cumberland ford, seem to be composed, so far as they have yet been observed, of conglomerate or an equivalent sandstone, capping the ridge, with sub-carboniferous limestones and shales forming the base.

Beyond this range of limestone and conglomerate, and between it and the Tennessee line, in the so called Log mountain, the geological formation belongs to the same Coal Measures which exist on the northwest of this uplift of the lower rocks, as represented in section No. 2, with this peculiarity: that there appears to be, so far as I have had an opportunity of examining it, very little hard or heavy bedded rock—the greater part of the body of the Log mountain being composed of shales and thin bedded shaly sandstones, even to the summit of this mountain, which is higher than the Pine mountain itself. On Hignight, a branch of Yellow creek, in the lower part of the mountain, where its waters have partially laid bare a section of the strata for about thirty feet, it has exposed several beds of coal lying in close proximity, making in all eight or nine feet of coal. This coal was reported to be twenty feet in thickness by the hunters who had observed it some years ago, during some of their excursions in this wild and unfrequented part of the Cumberland range of mountains. When I came to examine it in person I found that several feet of intervening shale and sandstone were included in the supposed twenty feet of coal, thus:

| | *Feet.* | *Inches.* |
|---|---|---|
| Sandstone, - - - - - - - - - - - - - | 6 | |
| Shale, - - - - - - - - - - - - - - | 6 | |
| Coal, - - - - - - - - - - - - - - | 3 | |
| Clay parting, - - - - - - - - - - - - - | | 4 |
| Coal, - - - - - - - - - - - - - - | 3 | |
| Fire-clay, - - - - - - - - - - - - - | 1 | |
| Schistose sandstone, 1 foot 6 inches to - - - - - - | 2 | |
| Shale, - - - - - - - - - - - - - - | 5 | |
| Coal, top only seen, - - - - - - - - - - | 1 | |

While in this neighborhood I also examined the supposed location of the notorious "Swift mine," on the other or north-west side of the same mountain, where the Indians are said in former times to have made a reservation of thirty miles square, on a branch of the Laurel fork of Clear creek. Benj. Herndon, an old explorer, and a man well acquainted with the country, guided me to the spot where the ore was supposed to be obtained by the Indians, and afterwards by Swift and his party. It proved to be a kidney-shaped mass of dark grey argillaceous iron-stone, containing some accidental minerals sparingly disseminated, such as sulphuret of zinc and lead, with a white powder, which proved, on examination, to be a hydrated silicate of alumina.

This ore originated in a thick mass of dark bituminous argillaceous shale, with some thin coal interstratified, that occurs about five hundred to six hundred feet up in the Log mountain.

I also examined, in the same vicinity, a supposed locality of granite. The rocks mistaken for granite proved to be a hard, fine-grained silico-calcareous rock, and carbonates of lime and protoxide of iron.

The richness of the soil on the slopes, and even on the summit of the Log mountain, is matter of surprise—supporting a heavy growth of

Walnut, Oak, Cherry, Poplar, Locust, and Chestnut. The black, rich mould of the Log mountain is owing to the prevalence of dark carbonaceous shales, which no doubt contain more or less lime, either in the substance of the shale itself or derived from the calcareous segregations therein imbedded.

The Log mountain and its peculiar formation extends into Harlan county, and is continued under the name of the Big and Little Black mountain, from south-east to north-west, until it reaches the Virginia line.

It is, doubtless, in the extension of these Coal Measures, that the reported thick coals, (fourteen feet,) on the Clover-lick branch of the Poor fork of the Cumberland river, have their origin. The Pine mountain range, which extends completely across Harlan county in a parallel course, is composed, as in Knox county, of conglomerate and millstone grit sandstone, on its summit, resting on limestones and marly shales of the sub-carboniferous group, alternating occasionally with sandstone; all dipping at a high angle of from 25° to 30°, the direction being, near the Cumberland Ford, about south 20° east. For this reason the summit and south-east slope of the Pine mountain range is a poor silicious soil; and for the same cause the land is very productive along the calcareous bench on the north-west slope; but the declivities are, for the most part, so abrupt that it is only locally susceptible of cultivation.

On the waters of Clear creek, in the vicinity of the Log mountain, and also in the valley between the White and Kitt mountains, detached pieces of soft, talcous slate have been picked up; but as these, so far as I have seen, are found in situations evidently the resort of the aborigines, and the rock is of that soft nature and composition which renders it easily fashioned into pipes, ornaments, and utensils, that will withstand heat, there is strong reason for believing that it has been brought by them from the gold region bordering on North Carolina, Tennessee, and Georgia, not more than seventy or eighty miles distant, in a direct course. Nevertheless, since there seems to be, from good authority, an abrupt anticlinal axis in the valley between the White and Kitt mountains, the strata dipping on either side at high angles, in opposite directions, there is a possibility that such rocks may, hereafter, be found in place in Kentucky, in the gorges of some of these mountains.

Beautiful samples of close-textured, concentric-structured cannel coal are found on the head of Dorton's branch, that empties into the Cumberland river three-quarters of a mile below the Cumberland Ford. An analysis of this coal gave,

| | | |
|---|---|---|
| Specific gravity, | 1.255 | |
| Total volatile matter, | | 42.9 |
| Coke, (compact, slightly altered in form,) | | 57.1 |
| | | 100.0 |
| Moisture, | 2.0 | |
| Volatile combustible matter, | 40.9 | |
| Fixed carbon in coke, | 55.1 | |
| Ashes, (orange-colored,) | 2.0 | |
| | 100.0 | |

It has a most brilliant surface, and smooth conchoidal fracture. Fine specimens of black fossiliferous limestone, containing *Productus* and Orbicula, occur on the waters of Straight creek, on both sides of the mountain, bordering on Harlan and Clay counties, which are susceptible of a polish, and therefore applicable as a black marble; the fossils showing frequently pearly white lines and surfaces against a black ground.

On the waters of Yellow creek, within about two miles of the Cumberland Gap, the strata are wrinkled and folded, and a two-foot four-inch leafy coal is inclosed between beds of shale.

Where the Cumberland river breaks through the Pine mountain range the rocks dip south 20° east, at an angle varying from 25° to 30°. The limestone is some three hundred feet above the river, capped with conglomerate, and underlaid by marly shales and sandstone. From the geological structure of this mountain it is not likely that any accessible beds of coal can be reached on the south-east side; possibly some may be discovered on the north-west, but these are likely to dip into the hill so rapidly that they can only be worked by inclined planes, and will therefore be troublesome to drain, and the beds will be very apt to be contorted.

The massive sandstone of the summit of the mountain, and the south slope, is occasionally overlapped in that direction with shale. No limestone can be reached on the south, as it bassets towards the north-west.

The Clear creek "Sulphur Spring" was tested at the fountain head. There appears to be little or no free sulphuretted hydrogen in this water, as acetate of lead is not blackened by it. The sulphur which it contains may be a trace of sulphuret of alkali; but, as I had at that time no nitro-prusside of sodium amongst the re-agents, I was not able to test for alkaline sulphuret with this re-agent. Bi-carbonate of lime and magnesia, with traces of sulphates and chlorides, are its other ingredients. This mineral water will probably be found serviceable in the cure of diseases of the skin, malignant ulcers, and other similar complaints.

Where the Cumberland river sweeps the south-east base of the Pine mountain for some miles the rocks in view are mostly shaly, with the prevalent dip to the south-east.

About six or seven miles up the valley, cliffs of sandstone come down to the river, with a more moderate dip, and appear in the shape of watch-towers and battlements flanking the escarpments. Further up some out-crops of coal make their appearance. One of the best which came under my notice, near Letcher P. O., is two feet nine inches thick, lying about forty feet above the river. It has a bright surface and remarkable clearage at about 80° from the plane of bedding, which gives it the appearance of being almost on edge, but the actual angle of dip here is only about 5°. A bold chalybeate spring issues from beneath the coal, which, notwithstanding its proximity to the coal, appears to be free from *sulphate* of iron, as chloride of barium gives no perceptible precipitate in the water. It seems to be a nearly pure bi-carbonate of the protoxide of iron, which gives it value as a tonic and antiperiodic mineral water. At a mill half a mile below this there are some thick shaly beds alternating with sandstone, dipping south 45° to 50° east, at an angle of about 25°. Twelve miles below Harlan Court House there is an immense bank of shale, with some thin-bedded sandstone dipping south 20° east, at an angle of 21°; and a mile further schistose sandstone is seen dipping south, at an angle of 10°. Five miles beyond is an extensive bed of black shale, with appearance of coal, followed by sandstone nearly horizontal. The finest beds of coal in Harlan county are undoubtedly in the range of the Little Black mountain, on the Clover fork, Clover lick creek, Catlines, Meadow, and Lick branches, where the beds vary from three to six feet or more.* In fact, more or less coal will undoubtedly be found on most of the streams coming in from the Big and Little Black mountains; and, from the large blocks of cannel coal found on some of the streams in this part of Harlan county, there must be a good bed of cannel coal in the adjacent hills.

A section obtained on the Clover fork of Cumberland, near the Three Forks, presented the following strata:

| | |
|---|---|
| Sandstone in cliffs, - - - - - - - - - | 20 to 30 feet. |
| Argillaceous shales, alternating with sandstone; some ash-colored shale with thin coal, - - - - - - - | 30 feet. |
| Shale, with argillaceous iron ore, - - - - - - - | 6 feet |
| Sandstone, a few feet. | |
| Dark bituminous shale, with thin coal near the bed of the river. | |

In the pass over the Pine mountain, by the War gap, leading into Perry county, a great deal of loose sandstone is seen on the southern ascent; but probably, in consequence of the strong south-easterly dip, none shows itself in well exposed ledges or cliffs. On the very top are heavy blocks of conglomerate.

Ledges of sub-carboniferous limestone were encountered about one-third of the distance of descent on the north-west declivity, six to seven hundred feet above the principal streams. The descent is very abrupt; a bridle-path, leading in a circuitous manner, constitutes the only State road from Harlan C. H. into Perry county.

A rich black calcareous soil always marks the junction of the sub-carboniferous limestone and shale with the overlying sandstone and conglomerate.

No sooner have you reached the foot of the Pine mountain than you begin the ascent of the Kentucky mountain, which is, however, lower than the Pine mountain, and appears to be already beyond the great south-west and north-east dislocation, since it is composed of the Coal Measures overlying the conglomerate, and no sub-carboniferous limestone is visible on either slope, so far as I have yet seen. Here the Middle fork of the Kentucky river takes its rise, under the name of the Laurel fork. Some thin coal crops out on this water course, which is here a mere rivulet, the State road running for long distances in its very bed.

Near Henry Lewis', on Tred's branch of Laurel, at the base of

*One bed is reported to be fourteen feet thick.

Lovely mountain, in Harlan county, a bed of coal was seen, three feet five inches thick, with a clay parting ten inches from the bottom: in all, three feet of good coal, partly of a compact, close-textured variety, like cannel coal, and partly bituminous. The compact coal reposes on the clay parting. The floor is ash-colored fire-clay, with remains of Calamites and other fossil plants; the roof is an argillaceous shale, running upwards into sandstone. Below this exposure, on the main creek, remarkably thin bedded sandstone comes out near the water level, which can be obtained in large thin slabs, that have been employed for covering bee-hives. These layers are overlaid by thicker bedded sandstone.

A bed of coal of similar quality and thickness to that mentioned as occurring on Tred's branch also crops out on the other side of the ridge watered by Greasy creek.

The York mountain is composed of shales and sandstones. Near its top some good argillaceous iron ore was observed. Fragments of coal were observed nearly all the way up the White Oak creek; the debris of beds in place in the adjacent hills.

At the junction of Coon and Wolf creeks the same appearances presented themselves, derived in part from a four-foot bed of coal which is in place two and a half miles above its mouth, and from another which crops out in the bank of a branch emptying into Wolf creek. A mile and a quarter down Coon creek another bed of coal is in place; indeed, beds of coal occur on all the branches in this part of Perry, viz: on Wooton's, McIntoshes, Messer, Big, and Coal creeks; since, even where the coal is not seen in place, washed fragments are to be found amongst the debris in the creek bottoms. The bed on Coal creek is four feet thick. On Big creek thick and extensive beds of black bituminous shale are frequently exposed.

The boundary line between Harlan, Perry, and Clay counties is quite falsely represented on the present maps of Kentucky. Coon and Wolf creeks form the boundary between Clay and Perry—the line passing by what is known as the "Bonnet Rock," on Coon creek.

On the south side of the North fork of the Kentucky river the main coal of the centre of Perry county lies about one hundred feet above the river. It has a clay parting of one or two inches ten inches from the bottom; the total thickness of the coal being four feet and a half to five feet.

Near the top of the ridge dividing the waters of the Elisha fork of Big creek and the Coal branch, there are considerable quantities of argillaceous oxide of iron.

One mile above Hazzard, in the cut of the road, on the north side of the Kentucky river, and about fifty or sixty feet above it, a bed of coal, three feet five inches in thickness, is exposed. It has several clay partings, and the coal does not appear to be of very good quality. The base of the Kentucky ridges, for thirty to fifty feet, in the vicinity of Hazzard, are composed of dark grey shaly rocks, overlaid by schistose sandstone passing upwards into heavier beds of sandstone, succeeded by shales containing argillaceous oxide of iron. The stratification is much of the same character the greater part of the way to Carr's fork, and beyond it; also in the hills adjacent to Ames' fork of Big creek. Two beds of coal, at least, are associated with these lower shales.

In Perry county, near Hazzard, borings have been carried, for salt water, four hundred feet below the bed of the Kentucky river, and brine obtained, yielding a bushel of salt from eighty-five gallons. Gas in copious volumes issued with intermitting force from the aperture, which facilitates the elevation of the salt water to the surface. At present, however, there seems to be but very little salt made at this well—for reasons unknown to me.

On Macy's creek there is good freestone for building purposes. Some calcareous septaria are disseminated in the shales, both on the Kentucky and on Big creek.

At the mouth of Leatherwood creek salt water was reached at one hundred feet, but not very strong; the borings were afterwards sunk by Brashears to four hundred and ten feet, or about the same distance below the bed of the Kentucky river as the adjacent ridges are elevated above the river, at which depth a fine brine was reached, yielding, when economically worked, a bushel of salt from sixty-five to seventy gallons. The borings are chiefly through sandstone, with a few soft shaly partings. At fifteen or twenty feet a bed of coal and shale was passed through, five to six feet in all; probably the same bed which shows itself in the river two or three miles below. A thick bed of coal is also reported at one hundred and sixty feet. The conglomerate is supposed to have been reached in these borings. No thick beds of coal have been discovered in the adjacent hills above the river. Over a thin bedded sandstone, situated forty to fifty feet above the river, twelve to fourteen inches of ccal crop out.

Two miles above the mouth of Leatherwood creek, on the north side of the Kentucky river, one foot of coal shows itself below a bench of sandstone, fifteen to twenty feet above the river, resting on ash-colored shale. One mile further up stream a good section is exposed of shaly sandstones, overlaid by thicker beds of sandstone.

Four miles below Rockhouse creek, in a ravine, at an elevation of about fifty or sixty feet above the river, two to three feet of coal bassets between beds of shale. Not far below Rockhouse the sandstones become more solid, and are exposed in high escarpments.

Near the confluence of Ring's creek very thick beds of ash-colored shale, at an elevation of sixty to eighty feet above the river, contain ferruginous and calcareous septaria, and saline oozings and crystallizations of sulphate of alumina and iron. Chalybeate springs are also of frequent occurrence in this part of Perry county.

Eleven miles below Whitesburg, sandstone, though thin bedded, forms conspicuous benches along the river. Three or four miles above this, thin, imperfect seams of coal are compressed between layers of sandstone, much in the same manner as the escarpment of the Finnie Bluff, in Union county. The out-crop of several thin coals are also visible in this vicinity; and indeed every few miles, to within a short distance of Whitesburg.

Borings have also been made for salt water at Whitesburg, and brine obtained at three hundred feet; at four hundred feet it yielded a bushel of salt from one hundred and twenty-five gallons. It is intended to carry these borings deeper. The decomposed out-crop of a thin coal shows itself five and a half miles above Whitesburg; and similar appearances were also seen two miles higher up. Five and a half miles from the source of the Kentucky river a coal of three to four feet is reported, which, however, I did not have an opportunity of examining. This is the thickest coal known, at present, on the head waters of the main branch of the Kentucky river.

From Joel Wright's, three and a half miles below the spring which forms the source of the main branch of the Kentucky river, I made an approximate measurement with the pocket level to the top of the Sounding gap, and found it to be, in all, one thousand and seventy-two feet, and obtained the following section:

| | |
|---|---|
| At 1072 feet. | Conglomerate sandstone, top of the Sounding gap.<br>Boundary line between Kentucky and Virginia. |
| At 1015 feet. | Red and grey shales. |
| At 900 feet. | Road above Geo. Bentley's house. |
| At 875 feet. | Green and red shales. |
| At 800 feet. | Corner of Bentley's fence, on road. |
| At 775 feet. | Highest appearance of limestone, seen on the road. |
| At 756 feet. | Top of main body of sub-carboniferous limestone. |
| At 700 feet. | Bluff bed of sub-carboniferous limestone. |
| At 680 feet. | Lowest appearance of upper beds of limestone. |
| At 535 feet. | Road where county line crosses. |
| At 510 feet. | Road above spring. |
| At 500 feet. | Spring—the source of the main branch of the Kentucky river. |
| At 485 feet. | Forks of the road. |
| At 400 feet. | Fourth house—Geo. Bentley's little farm. |
| At 200 feet. | Third house—Hull's? |
| At 145 feet. | Second house—H. M. Bentley's. |
| At 100 feet. | First house—H. T. Bentley's. |
| At 0 feet. | Kentucky river, at Joel Wright's. |

High cliffs of conglomerate and sandstone rise on either side above this pass into Virginia; the highest points, by estimation, being probably five hundred feet above the summit of the road where it passes over the Sounding gap. If the fall of the Kentucky river from Joel Wright's to the mouth of Leatherwood be at an average rate of eight feet to the mile, (assumed,) then the Sounding Gap is two thousand four hundred and seventy-seven to two thousand five hundred feet above tide water; and if the highest points are five hundred feet (assumed) above the pass through the gap, then the summits of this part of the Cumberland range are about three thousand feet above tide water in the gulf of Mexico.

According to Capt. May, who constructed the road over the Sounding gap into Virginia, this is the lowest and easiest grade of this range of the Cumberland mountain. His measurements make it eight hundred and ten feet above the Elkhorn fork of Big Sandy river, starting his level only two hundred and twenty-three feet below the road where the county line crosses in the preceding section.

On the Shelby fork of Big Sandy, in Pike county, a two-foot coal lies under a cliff of sandstone, about thirty-five to forty feet above the bed of that stream. This coal was on fire for upwards of two years, and the smothered combustion has produced a kind of natural coke. In samples which I procured from this bed, it is worthy of note, that on the same specimen the cellular structure of coke can be observed almost in juxta-position with portions presenting the usual appearance of unaltered coal, showing the unsoundness of the argument which has been brought against the natural coke of Virginia being a coal altered by heat, because some parts of the bed have the appearance of ordinary coal.

Efflorescences of salt show themselves for several miles on the Shelby fork of Big Sandy; this, together with noted Buffalo licks, led to the belief that salt water might be obtained by boring. An attempt was made by Captain May; after reaching a depth of one hundred and forty feet the auger got fast, and the boring was discontinued.

No coals have yet been observed on the Shelby fork of Big Sandy of more than two and a half to three feet in thickness.

The ridge which divides the waters of this stream from Island creek is four hundred and ten feet to the gap through which the road passes. The upper one hundred and sixty feet are composed of alternations of schistose sand and shale, with three benches of thicker bedded sandstone. A reddish shale, under the upper sandstone, contains some blocks of impure iron ore. The lower two hundred and fifty feet of argillaceous shale incloses large septaria sandstone, most of which is schistose, forms a solid bench of twenty-five to thirty feet, with two beds of coal under it—the upper two feet, and the lower four inches—with thirty-five feet of schistose argillaceous sandstone and shale between the two beds and beneath the whole. The highest part of the ridge must be from two to three hundred feet higher than the gap through which the road passes. Thin layers of carbonate of iron are disseminated in the shale over the lower coal, while the upper part of the shale has only thin bands of sandstone interstratified.

On Chloe creek, nearly opposite Pikeville, a workable coal, of fair quality, crops out under sandstone.

Seven miles above, a bed of coal lies in the bed of Big Sandy river, and a four-foot coal is reported at the forks of this river, all in Pike county.

About sixty feet above the bed of Big Sandy, near its junction with Island creek, are heavy ledges of sandstone, with grey shale both above and below it, including very large masses of calcareous septaria, which may afford a good substitute for limestone where this rock is absent.

Four miles below Pikeville a bold cliff of schistose sandstone juts out, fifteen feet above the river, with decomposing layers underneath that indicate saline efflorescences. These beds probably overlie the thicker bedded sandstone, higher up on Big Sandy, which has been brought down by the westerly dip that seems to prevail in this part of Pike county.

The bench of sandstone at William Cecil's farm is an excellent freestone for building purposes.

Five miles below Pikeville a bed of coal twelve to fourteen inches thick underlies a concretionary sandstone, at an elevation of sixty to eighty feet above the river. Here the hills are much lower than at Pikeville.

Seven miles below Pikeville there is a very heavy body of rusty ferruginous shale, nearly one hundred feet thick; and a short distance below this a thick bed of coal lies in the hills, ninety-six feet above the river, with two clay partings, dividing the coal into three members, the lowest being three feet, the middle one foot six inches, and the top one foot three inches, making five feet nine inches of coal in all. This coal has a roof of schistose argillaceous sandstone, containing fossil Calamites and some carbonate of iron, about ten feet thick, over which are ledges of sandstone, thus,

| | *Feet.* | *Inches.* |
|---|---|---|
| 1. Thin bedded sandstone or flagstones. | | |
| 2. Schistose argillaceous shale, containing Calamites and carbonate of iron, about - - - - - - - - - | 10 | |
| 3. Coal—upper member, - - - - - - - - - | 1 | 3 |
| 4. Grey argillaceous shale, - - - - - - - - - | 2 | 6 |
| 5. Black bituminous shale, - - - - - - - - - | 1 | |
| 6. Coal—middle member, - - - - - - - - - | 1 | 6 |
| 7. Clay parting, - - - - - - - - - - - | 1 | 6 |
| 8. Coal—lower member—ninety-six feet above Big Sandy, - | 3 | |
| 9. Fire-clay—floor of coal. | | |

The dip of the strata here is a little east of north, at the rate of from 3° to 5°. The lowest member seems to be of a superior quality to the middle and upper members.

From the geological reconnoissance of Knox, Harlan, Perry, Letcher, and Pike counties, it appears that the Kentucky ridges, to the north-west of the Pine mountain and its equivalent ranges, are composed, for the most part, of a succession of thick beds of schistose sandstone and shale overlying the saliferous group that pitch beneath the water courses, while the Pine mountain, together with the corresponding ranges, extending to the Sounding gap, are composed, in their upper part, of conglomerate and sandstones of the millstone grit series, resting on sub-carboniferous limestone and associate marls, shales, and sandstone forming the base of this range, all of which have been dislocated by two vast parallel faults, running from south-west to north-east, and heaved up more than one thousand feet along the north-west rent, receiving, at the same time, an inclination to the south-east, where it abuts against an immense body of dark shaly rocks, including thick beds of coal, constituting the Upper Coal Measures of the Log, Big, and Little Black mountains.

In the depression between these two last ranges, and in a direction nearly coincident with the direction of the fault and strike line, the Cumberland river finds its way from the Stone gap to the Cumberland ford, where it breaks through the chain of the Pine mountain, and then turning nearly at right angles to the line of strike, it pursues its course over the various members of the Coal Measures, until it again sweeps the conglomerate at their base. Pitching over an escarpment of that rock, at the falls of the Cumberland, in Pulaski county, and undermining the subordinate shales, it soon dashes over beds of sub-carboniferous limestone at the shoals, before winding its way to the older fossiliferous rocks of Russell and Cumberland counties.

The most important coal region of Pulaski county is above the shoals, not only adjacent to the Cumberland river, but on many of the creeks and branches putting into the Cumberland, both on the north and south.

The base of the geological sections in this vicinity, for one hundred and fifty feet, is composed of sub-carboniferous limestone; and one hundred and fifty feet above the limestone, or three hundreed feet above the Cumberland, the main bed of coal comes in. It varies from four to five feet in thickness. Both the floor and roof are dark bituminous shales; and forty feet above the coal is a bed of conglomerate sandstone, passing into yellow sandstone, which extends to within four feet of the top of the ridge, which is four hundred and nineteen feet above the Cumberland river. Twenty-five feet under the main coal is a thin coal from six inches to one foot in thickness; and forty-five feet lower another bed of coal from eighteen inches to three feet;

which is, therefore, about ninety feet above the sub-carboniferous limestone.

The main coal has been entered at several places, and mined to a considerable extent, chiefly for the Nashville market, by Clark, Wait, Doyle, Fox, Bradley, Stringer, and others.

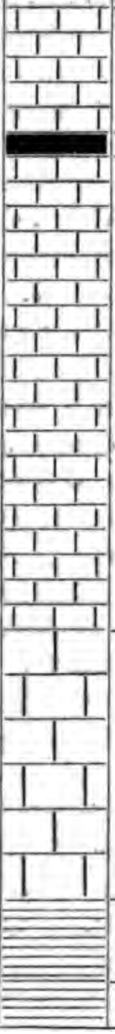
An analysis of this coal for volatile matter, coke, and ashes, gave the following result:

| | | |
|---|---|---|
| Specific gravity, | 1.293 | |
| Total volatile matter, | | 39.00 |
| Coke, (bright, slightly inflated,) | | 61.00 |
| | | 100.00 |
| Moisture, | 3.00 | |
| Volatile combustible matter, | 36.00 | |
| Fixed carbon, | 57.00 | |
| Ashes, (light grey,) | 4.00 | |
| | 100.00 | |

A few inches of the upper part of the bed is close-textured, like cannel coal. In some of the entries this kind of coal amounts to ten inches, and even eighteen inches or two feet, of the upper part of the bed—the ordinary variety measuring four feet two inches.

Fine bodies of coal land lie between Buck creek and Bear creek; also, on Beaver, where the main coal is even thicker than immediately on the Cumberland river.

The rocks decline rapidly to the south-east, so that the black shales lying over the coal and below the conglomerate are at the water's edge below the falls of the Cumberland, in Whitley county, where there is the following section:

| Feet. | | Inches. | Feet. | |
|---|---|---|---|---|
| 155 |  | | | Sandstone. |
| | | | 10 | Coal, 10 inches to 3 feet. |
| | | 90 | | Sandstones forming the escarpment above the falls of the Cumberland river. |
| 65 | | | | Top of the falls of the Cumberland. |
| 18 | | 48 | | Massive beds of conglomerate over which the waters of the Cumberland river fall. |
| 6 | | 12 | | Black, thinly laminated shale, with clay iron-stones, &c. |
| | | 6 | | Silicious shale at foot of the falls. |

The *perpendicular* fall is sixty-two feet; the fall and rapid seventy feet. The twelve feet of shale under the conglomerate is the repository of the notorious ore which it was professed contained a quantity of silver equal to from eighteen to twenty grains in an ounce. I regret to say that the chemical examinations that have been made of this ore do not confirm these statements.

The ore is essentially a protocarbonate of iron, containing the following constituents:

| | | |
|---|---|---|
| Moisture, | 0.40 | |
| Carbonic acid, | 31.10 | |
| Protoxide of iron, | 50.17 | 42. of iron. |
| Peroxide of iron, | 5.40 | |
| Lime, | 0.56 | |
| Alumina, | 0.70 | |
| Magnesia, | 0.36 | |
| Insoluble silicates, | 11.20 | |
| Loss, | .11 | |
| | 100.00 | |

There are some incidental minerals, in small quantities, disseminated irregularly through this ore, which do not belong to its essential composition, viz: sulphuret of zinc, sulphuret of iron, and perhaps traces of sulphuret of lead, antimony, and arsenic, together with a white powdery mineral which was mistaken for chloride of silver, but which is, in fact, a hydrated silicate of alumina allied to the mineral *Scarbroite*. The silver which professed to be extracted from this ore must have been derived either from argentiferous lead, employed in large quantities to cupel ("refine") the metallic ingot of iron ("prill") reduced previously from the ore, or it was fraudulently introduced during the process of smelting or refining, since traces of sulphuret of lead, that might be present in the ore, even if argentiferous, could not supply more than a small fraction of a grain to the ounce of ore.

These same shales supply, almost at every locality where it out-crops in the "Texas District," or southern tongue of Pulaski county, quantities of this carbonate of iron, even in more considerable masses than at the falls of the Cumberland: as for instance, on the Grassy gap survey, on the head of Indian creek; Rock House valley; Sam's branch of Beaver; Sloan's branch of the South fork. At the first of these localities the quantity, if fairly exposed, would probably be equal to a continuous band of from eighteen inches to two feet, and, since the land is well timbered with White Oak, Chestnut, Pine, and Poplar, and probably workable coals not far off, this region is worthy the attention of the iron manufacturer. The bed of coal which is immediately in connection with the shale affording the iron ore is only some six inches or a foot thick, but the place of the main coal of Pulaski county comes in about forty feet lower. It may not, however, be as thick in this part of the county as at the mines above the shoals; indeed, the indications rather lead to the inference that it will not be found to be more than three feet. The measurement of the ridges in the vicinity of Sloan's gave the elevation at three hundred and seventy-eight feet above the camp, below Sloan's house, which would make them about from five hundred and eighty to six hundred feet above the Big Sandy branch of the South fork, and about thirteen hundred feet above tide water. The buff limestone, overlaid by greenish grey marly shales, is one hundred and twelve feet above Camp, therefore two hundred and sixty-six feet below the top of the ridge over which the Jacksboro' road passes, and the junction of the sandstone and shales one hundred and fifty-two feet under the same, and one hundred and fourteen feet above the buff limestone.

Several good chalybeate springs have their source in Pulaski and Whitley counties, from the geological horizon of the shales and ironstone; some of these were tested at the fountain head, and found to contain carbonate of the protoxide of iron, with traces only of chlorides, and possessing feeble de-oxidizing properties.

There appear to be two, if not three, distinct shale beds containing iron ore, in Pulaski county—one fifteen or twenty feet above the sub-carboniferous limestone, and one about ninety feet—but the upper bed is probably the most productive. Where the ore is most abundant the coal seems to be thinnest.

In the Pitman range of hills, which form the divide between Pitman creek and Buck creek, in Pulaski county, there are several beds of coal; one, which lies about one hundred and fifty feet above the limestone, measures three feet three inches, including a clay parting and a thin band of sulphuret of iron, one foot from the top of the bed, or about three feet of coal in all. This bed is, probably, the equivalent of the main coal on the Cumberland river; another, about one foot thick, fourteen to fifteen feet higher in the hills; two more will probably be found below the three-foot bed, and one ninety or one hundred feet above it; there are indications also of iron ore above the three-foot coal, though it appeared rather earthy where the specimens were obtained. A kind of gravelly or pisiform iron ore was observed towards the base of the Pitman hills, but above the limestone. Some thin veins of lead ore have been found running through the limestone at the base of the Pitman hills.

On the Big lick the main coal has a clay parting of fifteen inches, with about one foot of coal above it, and forty-one to forty-two inches below. Near the mouth of Rockcastle river the coal is said to be of the same character.

At the Narrows of Rockcastle river, in Rockcastle county, where Dr. Graham is erecting a saw-mill, the formation is analogous to that described on the Cumberland, only the sub-carboniferous limestone lies lower—near the water courses—and the conglomerate sandstone is in greater force, forming vertical escarpments of one hundred and fifty feet. Here also the principal bed of coal is situated about forty feet under the escarpment of sandstone and conglomerate, but, so far as can be judged from a natural out-crop, not so thick as on the Cumberland. The two other inferior coals can probably be found here also.

Nearly the whole of the base of the hills on Rockcastle river, in the vicinity of the Narrows, is composed, for upwards of two hundred feet, of soft shaly materials, on which reposes one hundred and fifty feet of massive sandstone and conglomerate, forming, opposite Dr. Graham's mill, the conspicuous escarpment known as the "Bee Cliff," the summit of which is three hundred and fifty-five feet above the river, or about eleven hundred feet above tide water, without reckoning the slope above, which is at least twenty-five or fifty feet more. In consequence of the crumbling away of the shaly beds supporting this enormous weight of sandstone and conglomerate, the cliffs are rapidly undermined, while immense masses become disjointed, and precipitated down the abrupt slope into the bed of Rockcastle river It is in this way that that stream has become so blocked up with rocks, varying from a few tons to the size of a large house, that in many places even a canoe cannot pass. This is the character of Rockcastle river for many miles, both above and below its Narrows, and imparts to the scenery of that region the bold and romantic character for which it is justly celebrated. The wild and retired state of the country, together with the saline exudations and licks that appear at several localities on Rockcastle river, cause this country to be a great resort for every kind of game; the river is full of excellent fish, hence it is a favorite hunting and fishing ground, not only for the settlers of the county, but for the lovers of the chase from the blue grass districts of Kentucky.

Several excellent chalybeate springs occur, also, on Rockcastle river.

The same coals which have been described on the Cumberland have been traced, also, on the waters of Indian creek, in the south-eastern part of Pulaski; where there is also carbonate of iron and kidney-shaped argillaceous iron ore in considerable beds, occupying, apparently, the same geological position as the ore beds of Nolin, in Edmonson county.

Almost everywhere in the southern neck of Pulaski county, one hundred and fifty to two hundred feet beneath the table land, a tangled growth of Mountain Laurel, *Kalmia Latifolia*, Franklinia, *Gordonia Pubescens*, a peculiar species of Baybush and Holly, *Ilex Opaca*, fringe the water courses; while on the ridges the growth is Oak, Chestnut, Pine, and Hickory.

On a branch of Indian creek, flowing into Jellico, near Shephard's, a good, bright, solid coal shows itself under ledges of sandstone two feet three or four inches in thickness, resting on fire clay.

The Jellico mountain, which is about one thousand five hundred feet above tide water, is composed entirely of Coal Measures; no limestone showing itself, even in the beds of the streams. There are at least four beds of coal in this range; one near the beds of the branches; a second about one hundred feet up; a third about half way up the mountain, with perhaps intermediate beds; and a fourth near the top—as loose blocks of coal are reported lying on the surface near the top of the Clear Fork mountain, which is about the same height as the Jellico mountain. On Briar creek, near the foot of the south-eastern slope of the Jellico mountain, a bed of black shale twenty feet in thickness includes carbonate of iron, one band of which is four inches thick; another about three inches, but more or less interrupted in its horizontal bedding; the same formation was also seen on the Sugar branch, above Perlegs, in connection with a seam of coal, lying in the bed of the branch. About one hundred feet above, in the Middle mountain, is another bed of coal, covered by grey shale; and another is reported about one hundred feet higher, on the other side of the same mountain.

On the Cumberland river, in Whitley county, opposite Williamsburg, the first eighty-five feet are composed of shaly rocks, resting on a bed of coal in the river, overlaid by fifty-five feet of thin bedded sand. Near the junction of the shale and sandstone, where the latter, as it frequently does, forms overhanging cliffs, efflorescences of sulphate of lime and sulphate of magnesia encrust the decomposing, receding layers of shaly rocks.

King's coal lies about two hundred and fifty feet up in a hill, on the east side of the Cumberland river, over a heavy bed of black shale, and covered by schistose sandstone and ferruginous shales. The total height of the hill in which the coal is situated is six hundred feet above the Cumberland river, or about one thousand five hundred feet above tide water. There are, no doubt, several other beds of coal in this hill, above and below King's coal. The levels show five benches of sandstone in this hill, with intermediate shale beds; the first at eighty-five feet, fifty-five feet in thickness; the second at one hundred and fifty feet; the third at two hundred and fifty feet; the fourth at three hundred feet; the fifth at five hundred feet. The shale over the second bench contains some limonite iron ore. Between the fourth and fifth a bed of coal can probably be found; and also between the second and third. The lower shale beds, near the river, contain considerable quantities of carbonate of iron.

On the head of Watt's creek, at the foot of Linn-camp mountain, several important beds of coal are reported; one, a four-foot bituminous coal, suitable for blacksmiths' use; one, a kind of cannel coal. Several out-crops of thin coal were observed on the Clear fork, eight to ten miles from Williamsburg; one of which lies fifteen feet above that stream, covered by grey shale and schistose sandstone, with heavy beds of black and ferruginous shales at an elevation of forty-five and sixty-five feet to eighty feet. Corresponding beds were noticed, also, near Briant's. At Falkner's mill the black shales, near the water level, no doubt overlie a bed of coal in or below the river.

While in this neighborhood specimens of supposed copper ore were submitted for examination, obtained in the Pine mountain, near the confines of Kentucky and Tennessee. It proved to be a hematitic iron ore of good quality; that from the head of Mud creek is a very fine cellular variety.

Near the base of the hills, bordering on Cane and Patterson's creeks, ferruginous shales are exposed, containing large quantities of argillaceous oxide of iron, of good quality; and disintegrated gravel of the same material is everywhere strewed along the road.

Limonite ores and carbonates of iron were also brought in for examination from Meadow creekand Watt's creek.

On Big Poplar creek, near William Evans', a nine-inch coal shows itself two feet above the water, covered by argillaceous shale.

In the vicinity of Williamsburg, along the Cumberland river; on Big Poplar creek; and in the vicinity of Boston, on the waters of Cane creek, there is some fine, level farming land; in this part of Whitley county, as well as in most of the mountain counties east of the junction of the sub-carboniferous limestone, millstone grit, and conglomerate, the farming property is confined, for the most part, to narrow strips of bottom land and the slopes of the mountains; often so abrupt that the ground admits of being plowed only in one direction—around the hill sides; otherwise the soil, in a few seasons, would be washed into the valleys. Extensive level farms, found mostly in the vicinity of the towns, are the exceptions to the general rule in the eastern coal region of the mountain counties.

The boundary line between Whitley, Knox, and Laurel counties is entirely falsely laid down on existing maps. Instead of starting, as it is represented, from a point on the Cumberland river where the eastern boundary of Pulaski crosses that stream; thence up the meanders of Laurel river to its confluence with Linn-camp; thence up Linn-camp creek to its source; thence north-east along the summit of Linn-camp mountain to the corner of Clay, it ought to start from where Cane creek empties into Rockcastle river, and run, according to the best authority I am able to arrive at, to the mouth of Linn-camp creek; thence up that stream to McHargue's mill; thence along the dividing ridge between Robinson and Richland creeks; thence south-west to the corner of Clay.

This is a sample of some of the egregious errors in the present geography of Kentucky which demand correction, and which has forced upon the geologist a task as laborious and expensive as the purely geological part of his duty—more especially since he has no system of rectilineal surveys to guide him; no base lines or meridian on which to erect his survey; nor any recorded township, or even county maps, upon which any reliance can be placed.

Carbonates of iron, with disseminated accidental minerals, similar in composition to the ores of Pulaski county, occur, also, in Laurel county, on the waters of Craig and Robinson creeks. The base of the section on the latter water course, near where the road from Williamsburg to London crosses, are black and grey shales, overlaid by five feet of sandstone, passing upwards into a soft brown sandstone, some fifty to sixty feet thick. About a mile north of this a few inches of coal are seen, under a similar sandstone, which prevails to within six miles of London, where dark grey, yellowish, and reddish-brown shales, with vertical jointed seams and scaly argillaceous iron ore, are again in place, like those described on Linn-camp creek, underlaid by thin bedded sandstone, which continues nearly to London.

On the waters of Laurel and Sinking creeks workable coals occur, that supply the town of London; one of these is, in all probability, the equivalent of the main coal of Pulaski.

Specimens of red oxide of iron were submitted for examination from Frazer's Knob. The quality appears good, but I have not yet had an opportunity of seeing the ore in place, to judge of the quantity.

An eighteen-inch coal crops out on the Town branch, in sight of London. Two miles further south a three-foot coal occurs about the same geological level.

In digging wells in the town of London, in Laurel county, a grey micaceous gritstone is struck at fifteen feet; a hard sandstone, with disseminated pebbles, is reached at twenty-five feet. This is, probably, the top of the conglomerate range which we have described while treating of the formations of Rockcastle river. Above this there appear to be shales containing some dark clay ironstone. Thirty feet above Wood's creek forty inches of good coal comes out under ash-colored argillaceous shale, with a bench of schistose sandstone sixty feet above it; a considerable part of the intervening space being filled with black shales. The bench of sandstone is ten feet thick, and resembles the sandstone seen near London. A little lower down, on Wood's creek, and on a branch not far from Pitman's, this coal measures four feet; near Brown's it is three feet.

The surface of the interior of Laurel is more level than the mountain counties lying to the east and south, in consequence of the softness of the materials overlying the conglomerate. The hills along our route were seldom over two hundred and fifty or three hundred feet above the water courses. Adjacent to Rockcastle river the country is, however, more broken with abrupt precipices descending to that stream.

On the White Oak branch of Little Rockcastle river, large quantities of argillaceous carbonate of iron are included in the shales both above and below a one-foot coal, and associated with a three-foot coal, which would be worthy the attention of the iron manufacturer, as five hundred acres of this land could be purchased of the owner, in 1855, for a dollar or a dollar and a half an acre.

It is probable that the conglomerate is, in many localities in Laurel county, replaced by shales with disseminated ironstone, as the former rock appears in an equal force along its strike line in its north-eastern extension, through Laurel county.

On the south-east side of Rockcastle river, on the Mt. Vernon road, the top of the buff beds of the sub-carboniferous limestone extend to the height of one hundred and two feet above that stream, with Archimedes limestone below at ninety-five feet. Above this ferruginous shale thin bedded and shaly sandstones extend to the height of three hundred and forty feet, including much silicious oxide of iron, while sandstones of the millstone grit, sixty feet in thickness, caps the section, extending to the height of four hundred and ten feet. The lower one hundred feet are occupied by the limestones and marly shales of the sub-carboniferous group, with some hydrated oxide of iron, especially in the shale, at ninety feet.

On the north-west side of this river the sub-carboniferous limestones could only be traced to an elevation of forty feet, where it is overlaid by a soft, incoherent, coarse conglomerate. Here the strata seem to have suffered from denudation, about the time of the deposition of the conglomerate.

Near the top of the hills, five miles from Mt. Vernon, in Rockcastle county, there is a dark grey carbonaceous sandstone, full of the remains of stigmaria; this has the lithological character of the salt bearing rock, but of course lies here in a position to admit of all or the greater part of the saline matter which it may have originally contained being washed out. Here the sandstone of the millstone grit can be traced to the height of four hundred feet above Rockcastle river, but the ridge extends some thirty to fifty feet higher. A mile or two further to the north-west, sub-carboniferous limestones are alone seen. This is the north-west limit of the Coal Measures in Rockcastle county. Some out-liers are, however, still found beyond, on the waters of Roundstone lick and Skeggs' creek.

In connection with these records of the geological reconnoissances of the Coal Measures of Kentucky, it remains for me at present only to notice those portions of Wayne and Clinton counties which belong to this formation.

The upper one hundred and thirty-three feet of the Wallace mountain, on the north-east side of Otter creek, in Wayne county, belongs to the Coal Measures. No coal was seen in this mountain, but it is probable a bed can be reached between forty and fifty feet below the top of the mountain.

In the ridge between Meadow and Sinking creeks coal three feet ten inches underlies a band of four to six feet of sandstone, over which is dark ash-colored shale. Symptoms of two other beds—one below and one above this coal—occur in the same ridge, but they are probably thinner coals.

In Sloan's hill, which is about eight hundred feet above the Cumberland river, at Mill-springs, or nearly thirteen hundred feet above the ocean, three feet of coal lies about one hundred feet below the top of this hill, or twelve hundred feet above tide water. A black shale has been discovered from twenty to twenty-five feet below the main coal of this ridge, which is associated, at least locally, with eighteen inches of coal. The immediate roof of the main Sloan coal is shale, but there are massive sandstones higher in the hill, and also below the coal. These coals can, undoubtedly, be found in the adjacent ridges wherever there is one hundred and twenty to one hundred and fifty feet of solid rock above the top of the sub-carboniferous limestone. Those hills which are less than five hundred feet above the Cumberland are not likely to contain any workable coal, unless they should prove to be implicated in local faults or down-casts of the stratification.

The main coal of the Short mountain, near the confines of Wayne and Clinton counties, is nine hundred and sixty-six feet above low water of the Cumberland river, at Rowena, or fourteen hundred and thirty-six feet above tide water. From the coal to the top of the Short mountain is ninety-two feet, consequently this mountain is fifteen hundred and twenty-eight feet above tide water. This coal is three feet ten inches thick, and yielded, by analysis of a specimen from Hoskins' mine,

| | | |
|---|---|---|
| Specific gravity, - - - - - - - - - - | 1.339 | |
| Total volatile matter, - - - - - - - - - - - | | 37.8 |
| Coke, (inflated,) - - - - - - - - - - - - - | | 62.2 |
| | | 100.0 |
| Moisture, - - - - - - - - - - - - | 2.0 | |
| Volatile combustible matter, - - - - - - - | 35.8 | |
| Fixed carbon in coke, - - - - - - - - | 55.2 | |
| Ashes, (purplish-grey,) - - - - - - - | 7.0 | |
| | 100.0 | |

The sub-carboniferous limestone comes in about ninety-six feet below the main coal, or thirteen hundred and forty feet above tide water, and eight hundred and seventy feet above low water of the Cumberland river at Rowena. This is, in all probability, the equivalent of the lower three-foot coal of the Cumberland coal miles, increased in thickness, since it lies within a few feet of the same distance above the sub-carboniferous limestone; if so, the main Cumberland coal will be found near the top of the hill. The proprietor proposes to construct a railroad from the Short mountain to the Cumberland river at Rowena. Coal shipped down the Cumberland at this point would avoid the obstructions at the shoals, which, until removed, must always form a serious drawback to all shipments of coal above these shoals, where eleven boats were wrecked at one time, in the spring of 1855.

The same bed of coal lies in the north face of Poplar Chalybeate mountain, five miles from Albany, in Clinton county, and in sight of Waid's or Long's gap, about the same height above the Cumberland river as in the Short mountain. Here the coal measures three feet eight inches at the out-crop. It has several streaks of sulphuret of iron running horizontally through the bed at this place.

The same bed shows itself, I am told, in the ridges adjacent to the Caney gap, about three miles from Albany. If so, this is about the most extreme westerly limits of the Coal Measures of Clinton county.

From what has been stated in regard to the geological position of the lower measures, with reference to the subordinate sub-carboniferous limestone in Clinton, Wayne, Pulaski, Rockcastle, and part of Laurel and Owsley counties, it is evident that the precise boundaries of their geological formations can only be laid down after a careful topographical map has been constructed of their geography, defining all the main ridges, and determining, accurately, their comparative elevations.

Though the soil derived from the Coal Measures of the eastern coal field can by no means be regarded as an unproductive soil, yet the limited amount of level arable land must necessarily restrict the agricultural pursuits of the people inhabiting these mountain counties, hence the development of their mineral resources becomes a matter of the first importance to them. There is every reason for believing, from the geological reconnoissance of the past season, that their resources in coal and iron—staple commodities of those nations of greatest prosperity—will, when fully developed, compare most favorably with those of any civilized country at present known on the face of the globe.

### SUB-CARBONIFEROUS LIMESTONE

### *Of Crittenden, Livingston, Lyon, Caldwell, and Trigg counties.*

In consequence of the loss of the greater part of the collection made in this part of Kentucky on the Cape May, and a failure in the receipt of other boxes left for shipment on the Cumberland river, but little more can be stated here than has already been said in the first Chapter.

I am only able to present now three chemical analyses of ores from this iron region of the Cumberland river, contained in Dr. Peter's Report, Nos. 139, 142, and 143. These are limonites or hematitic iron ores, containing essentially oxide of iron and water. They yielded from twenty-five to fifty per cent. of iron; the earthy silicious matter varying from nine to fifty-four per cent., with usually small quantities of alumina, lime, magnesia, carbonic and phosphoric acid, and alkalies; these latter ingredients being seldom over a fraction of a per cent. The general geological relations of these ores are treated of in the first Chapter; more particular remarks in regard to these ores will be given hereafter, when more of the ores shall have been analyzed.

I would recommend to the owners of furnaces who are desirous of obtaining an accurate knowledge of the constitution of any of their ores, and having the analysis recorded in the next Report, to forward specimens either to me or to Dr. Peter, of Lexington, Kentucky, in the course of this summer. At the same time it would be advisable that specimens of the limestone used as a flux, together with a few pounds of the pig iron and furnace slag produced from the ores, be included in the selection; as a comparative analysis of these, in connection with the ore, is required to supply all the information necessary to enable the manufacturer to judge whether the ore, flux, and carbonaceous matter are added in the due proportions requisite to produce the best iron, in the most economical manner.

Nine iron furnaces are in operation at present, working the limonite ores from the sub-carboniferous limestones of these counties. They produce, on an average, from six to seven tons of pig iron in twenty-four hours, and run about three hundred days in the year. The annual production from these furnaces will, therefore, be, as near as can at present be estimated, from sixteen thousand to eighteen thousand tons. At present charcoal is the only fuel employed, and the cost of the production of a ton of pig iron may be reckoned at $18. From one-fifth to one-twelfth of limestone is used as a flux. They employ about nine hundred to one thousand workmen in mining ore, coaling, working the furnaces, and delivering iron at the landing. Each furnace consumes the timber off two hundred to two hundred and fifty acres of ground annually, depending on the size of the trees; the charcoal costs, delivered at the furnace, about $4 per hundred bushels.

If these furnaces were so situated that they could employ coal as a fuel, instead of charcoal, that would net them $2 50 per ton, the cost of the production of pig iron could be reduced at least $5 to $6 per ton. This is an advantage which all iron furnaces possess located in the midst of a rich coal field. It is true the quality of the iron produced from coal is, as a general rule, inferior, but still it is sufficiently good for the principal articles of consumption; and, at any rate, can be made of a quality equal to the Scotch pig iron, which is manufactured from raw coal.

The Crittenden Spring, one of the finest mineral waters in the southern part of Kentucky, issues from the upper members of the sub-carboniferous limestone, at the rate of one pint in twelve seconds. The temperature of the water was found to be 61° F., while the temperature of the air was 79°. The water has a distinct alkaline reaction on litmus papers. Free, light carburetted hydrogen is copiously evolved, so that ten or fifteen cubic inches can be collected in a few minutes. The principal constituents are,

Free, light carburetted hydrogen, (saturated;)
Free sulphuretted hydrogen;
Chloride of sodium;
Chloride of calcium? and magnesium?
Sulphate of soda, (small quantity;)
Sulphate of magnesia;
Probably also small quantities of carbonate of soda;
Bi-carbonate of lime and magnesia?

To ascertain the presence or absence of other ingredients, as iodides and bromides, as well as to determine the proportions of the saline constituents and their state of combination, would require a full supply of the water collected by the chemist at the fountain head, with the proper precautions, and a subsequent thorough quantitative analysis made in the laboratory.

The Crittenden Spring appears to have considerable analogy in its properties to the celebrated sulphureous mineral water of Aix-la-Chapelle, but differs from it in temperature and in the presence of light carburetted hydrogen gas.

The Sulphur Spring of Livingston county issues in a ravine between ledges of grey sub-carboniferous limestone, while the adjacent ridges are capped with hard sandstone of the millstone grit. Temperature of spring 59° F., the air being 68° F. It is a saline chalybeate water, containing small quantities of the bi-carbonate of the protoxide of iron, along with notable quantities of chlorides and sulphates of magnesia and bi-carbonate of lime.

The Cerulian Spring is also situated at the foot of a hill of sub-carboniferous limestone, capped with sandstone, on the waters of Little river, in Trigg county. Its temperature was found to be 56° F., the temperature of the air being, at the same time, 80° F. It issues at the rate of one gallon to one and a half gallons per minute. It appears to have a very feeble alkaline reaction. This spring is strongly impregnated with both sulphate and chloride of magnesia, and contains, probably, also soda as a base united with the above acids; also bi-carbonates of lime and (magnesia?) It contains also a notable portion of free sulphuretted hydrogen.

Three miles east of this spring a bed of fine-grained, earthy limestone is interstratified in the sub-carboniferous group possessing hydraulic properties

I find myself compelled, for want of adequate time, to postpone the record of numerous details in regard to the sub-carboniferous limestone, and inferior rocks, until the publication of the next report.

A large collection has been made of the characteristic organic remains, from the various formations, which must necessarily, for the same reason, remain over for future description and elucidation.

D. D. OWEN, *State Geologist.*

# CHEMICAL REPORT

OF THE

# MINERALS, ROCKS, AND SOILS,

MADE BY

## ROBERT PETER, M. D.,

CHEMICAL ASSISTANT.

# INTRODUCTORY LETTER.

CHEMICAL LABORATORY OF THE GEOLOGICAL SURVEY,
*Lexington, Ky., September* 24, 1855.

DEAR SIR: I herewith transmit to you my Summary Report of the Chemical Analyses made for the Geological and Chemical Survey of Kentucky.

It contains the results of more than two hundred days of incessant labor, but yet exhibits the composition of a *very small proportion* of the valuable minerals of the State, as you will doubtless demonstrate in *your* forthcoming Report. Sufficient is shown, however, even in this brief and partial sketch, to prove the great wealth, *in substantial riches*, of the Commonwealth of Kentucky.

Blessed with the most fertile soil in the world, on its central geological formations; the decomposing soft limestones and marls of which continually renew its supply of phosphates, sulphates, and the alkalies, &c., &c., as they are removed by cropping; a great portion of its eastern and western boundaries include mineral wealth in the greatest abundance, in the form of iron ores, coals, limestones, clays, salt, &c., &c., of great variety, requiring only capital, skill, and industry, which they must eventually invoke to their exploration, to change the regions containing them—some of them now very sparsely settled and little known—into the locations of numerous and lucrative manufactories, and centres of an active and extensive commerce.

By an examination of the descriptions and composition of the iron ores which were analyzed, it well be seen that they are, generally, of the most profitable and productive kinds.

The limonites are in great variety; and almost all of them are comparatively soft and porous; thus, easily to be reduced in the furnace. Some with an excess of *silicious* matters, others of *calcareous;* and generally containing earthy materials enough to form a sufficient amount of the necessary furnace slag, (or cinder, so called,) either alone or with admixture of some of the neighboring poorer ores or limestones.

Very few of them contain much phosphoric acid, or other injurious ingredients; and even those which, at some furnaces, are considered "*impracticable*," or difficult to smelt, are found to be hard to manage mainly because of their richness itself; and require only the admixture of poorer ores, or some argillaceous, silicious, and calcareous substances, abundant everywhere, to flux them and make them yield their content of iron.

The proportion of this metal, in some of them, may seem to be small; but it is well known to practical men that the most profitable ores of iron are those which contain less than fifty per cent. of that metal; and many containing not much more than half that proportion are economically smelted.

The *black band* iron ores, from the lower portion of the State, and from Greenup county, are interesting. Most of them which were examined proved to be as good as those of Europe, from which iron is most cheaply made. A few disappointed the hopes which were excited by their appearance, and proved to be too poor in iron to be considered workable, or too much contaminated with phosphate of lime. Doubtless, in many parts of the extensive coal fields of the State, this valuable kind of iron ore, of good quality, may be found in great abundance.

The economy introduced into the iron manufacture, by the use of this ore, in Scotland, is illustrated by the celebrated David Mushet, in his voluminous practical "*Papers on Iron and Steel*," by the comparative statement of the burthen and produce, at the Clyde iron works, of two furnaces, blowing each for one week, and using pit-coal and the hot-blast, as follows:

| | *Tons.* | *Cwts.* | *Qrs.* |
|---|---|---|---|
| 1. With black band ironstone— | | | |
| Coals to the ton of iron, | 1 | 8 | 3 |
| Roasted ore, ("mine,") | 1 | 14 | 1 |
| Limestone, | 0 | 3 | 3 |
| 2. With clay ironstone— | | | |
| Coals, to the ton of iron, | 2 | 3 | 2 |
| Roasted ore, | 2 | 6 | 2 |
| Limestone, | 0 | 11 | 2 |
| Saving from the use of the black band— | | | |
| Coals, per ton of iron, | 0 | 15 | 3 |
| Limestone, | 0 | 7 | 3 |
| Additional produce of iron in the week, | 20 | 4 | 0 |

The iron manufacture in this State is only in its infancy. We now produce only charcoal iron, of the best quality, while we import, annually, immense quantities of *common* iron, for railroad and other purposes.

With the black band, or some of our other good fusible ores, and the use of coal and the hot-blast, the cheaper kinds of iron, so extensively used, could doubtless be made to great advantage in Kentucky, and thus a foreign drain on our capital would be checked, and a new source of wealth established. This will be found necessary for self-defence if our railroad improvements are much extended, as they doubtless will be; and will be the more easily effected as the price of labor, from well known causes, is becoming higher in Europe.

For this kind of manufacture those of our coals which contains but little sulphur, and less than five per cent. of ashes, would be well suited, more especially the variety called *dry* or *splint* coal, which abounds in our State, which need not be coked before it is used in the furnace, and thus is cheaper than coke. This kind of coal, while it does not soften or swell up much when heated, so as to choke up the furnace and check the blast, gives out much combustible gas to aid in reducing the ore, and carbonating the iron.

I have not thought proper to give a detail of the processes used in the chemical investigation; they have been various, according to the requirements of the specimen under examination—generally those described in that monument of industry and accuracy, the "*Handbuch der Analytischen Chemie, Von Heinrich Rose,*" (last German edition)—but sometimes modified to suit the circumstances of the case. In the separation and estimation of the alkalies, and the separation of magnesia from the alkalies—processes which so frequently occur in mineral analysis—the important improvements of Dr. J. Lawrence Smith, (detailed in Silliman's Journal,) were found to be greatly better than the old methods.

The total amount of carbon in the specimens of pig-iron was ascertained by means of iodine—a method with which I am not entirely satisfied. The phosphorus, in that metal, was estimated by solution in fuming nitric acid, and evaporation to dryness to render the silica insoluble, re-solution in hydro-chloric acid, and precipitation of the oxides of iron and manganese with sulphuret of ammonium and a sufficient quantity of caustic potash. The alumina and phosphoric acid, dissolved by the caustic solution, were separated by known methods—the latter being weighed as phosphate of magnesia.

In the examination of the *soils* it was thought proper to substitute, for the ordinary process of digestion in water, to ascertain the proportion of readily soluble matters, that of digestion for some weeks in water which had been saturated, under pressure, with carbonic acid gas. This plan was adopted in order more nearly to imitate the process of nature in the solution of the nutritious ingredients of the soil for the food of plants. The water which falls as rain, &c., being always charged with carbonic acid, the proportion of which is increased in it, when it percolates the soil, by the slow oxidation of the organic matters; and this, with the very small amount of nitric or hypo-nitric acid sometimes produced in the atmosphere during electrical excitements, and the soluble organic matters themselves, are the principal means by which the fixed or mineral elements of plants, indispensable to their organization, are dissolved and introduced into their tissues.

The investigation of the soils was not as thorough as it should have been, the time allotted to the chemical analyses having been nearly consumed by other objects before they were commenced; their examination was therefore too hurried, and consequently the proportions of some of their more minute ingredients, (of the most valuable also,) such as the chlorides, sulphates, and phosphates, were not, in all cases, separately made out.

Amongst the *ores*, the *coals*, the *rocks*, the *soils*, the *mineral waters*, *&c.*, &c., of the State, a wide unexplored field still remains for examination.

Hoping that this brief and imperfect investigation may be but the beginning of a still further and complete study of the geological history and the mineral riches of the State of Kentucky,

I remain yours respectfully,
ROBERT PETER.

David Dale Owen, M. D.,
*Principal Geologist of Kentucky.*

# A SUMMARY

OF THE

# CHEMICAL ANALYSES

OF

# Ores, Soils, Coals, Limestones, Pig-Iron, Iron Furnace Cinder, &c.,

OF KENTUCKY,

MOSTLY PROCURED BY DAVID DALE OWEN, M. D., PRINCIPAL GEOLOGIST OF KENTUCKY, AND ANALYZED BY ROBERT PETER, M. D., CHEMICAL ASSISTANT TO THE STATE GEOLOGICAL SURVEY.

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ARRANGED IN THE ALPHABETICAL ORDER OF THE COUNTIES IN WHICH THEY WERE OBTAINED.

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## BALLARD COUNTY.

No. 1—SOIL. *Labeled "Soil from heavy timbered land, southern part of Ballard county, Kentucky," between the waters of Bowles and west branch of Mayfield creeks.*

Color yellowish grey, or dirty buff, in its dried state. Carefully washed with water it left about forty-seven per cent. of *very fine sand*, which was nearly of the color of the soil; a larger proportion could doubtless be obtained by devoting more time to the washing, for it is so fine as easily to be washed away with the lighter particles, and to escape ordinary observation.

One thousand grains of the air-dried soil were digested, for about a month, in a closely stoppered bottle, at a temperature not above 100° F., in water which had been saturated under pressure with carbonic acid gas; the liquid, filtered and evaporated to dryness at 212° F., left 1.53 grains of *solid matter*, which had been dissolved by the acidulated water.

This solid *extract*, when treated with pure water, left of *insoluble matter*, 0.603 gr., which had been dissolved by the carbonic acid, and which was of the following composition, viz:

| | |
|---|---|
| Silica, | 0.137 |
| Carbonate of magnesia, | .259 |
| Brown oxide of manganese, | .117 |
| Alumina, oxide of iron, and traces of phosphates, | .067 |
| Potash, | .005 |
| Traces of carbonate of lime and loss, | .018 |

The portion of the extract which was dissolved by the water was of a dark brown color, and weighed 0.9 gr. when dried at 212° F.; when ignited over the spirit lamp a portion of it was burnt off, with a mixed smell of burnt animal matter and burning peat, leaving 0.4 gr. of fixed residuum. The composition of this *soluble* portion was found to be as follows:

| | |
|---|---|
| Organic and volatile matter, | 0.500 |
| Carbonate of lime, | .098 |
| Carbonate of magnesia, | .112 |
| Carbonate of manganese, | .051 |
| Alumina, oxide of iron, with traces of phosphates, | .007 |
| Potash, | .036 |
| Soda, | .067 |
| Loss, | .029 |

The lime, magnesia, oxides of manganese and iron, and the alumina and phosphates were, in the extract, doubtless combined with the organic acids, which are included above under the general name of *organic matter*, and which, when burnt off, leave most of these fixed substances in combination with carbonic acid. Water saturated with carbonic acid was used, in this process of analysis, to enable me to estimate the relative amount of soluble materials immediately available for the nourishment of vegetables. The water which falls from the atmosphere always contains some of this acid which, with the organic acids resulting from animal and vegetable decomposition, is the principal agent in the solution of the nutritive elements of the soil for the support of plants.

Had sufficient time been at my disposal I should have examined this soil more minutely, for other soluble ingredients, as ammonia, the nitrates, chlorides, and sulphates, but having nearly approached the end of the present term of labor, before the soils were commenced, I was obliged to be contented with a less extensive investigation.

One hundred grains of the air-dried soil, exposed to the temperature of 340° F., lost of *moisture* 1.84 grains. Treated in the usual manner, by digestion in hydrochloric acid, &c., its composition, dried at 340°, was found to be as follows, viz:

| | |
|---|---|
| Organic and volatile matters, | 3.040 |
| Carbonate of lime, | .034 |
| Carbonate of magnesia, | .461 |
| Carbonate of manganese, | .411 |
| Alumina, oxide of iron, and traces of phosphates, | 3.930 |
| Potash, | .108 |
| Soda, | .037 |
| Silica and silicates insoluble in hydrochloric acid, | 92.010 |
| | 100.031 |

No. 2—Soil. *Labeled "Soil from the north-western part of Ballard county, Ky., near Col. Gholson's."*

Color of the dry soil of a dark brownish grey. Washing with water gave about fifty-three per cent. of *very fine sand*, of a dirty buff color, which is doubtless only a portion. Treated with water acidulated with carbonic acid, as above described, this soil gave up 1.943 gr. of solid matter, (dried at 212°); which re-dissolved in pure water left 0.955 gr. of *insoluble matter*, which had been dissolved by the carbonic acid, of the following composition, dried at 212°:

| | |
|---|---|
| Silica, | .170 |
| Carbonate of lime, | .227 |
| Carbonate of magnesia, | .321 |
| Carbonate of manganese, | .200 |
| Alumina, oxide of iron, and traces of phosphates, | .037 |

The portion which dissolved in the pure water weighed, when dried at 212°, 0.988 gr. Heated to redness in a platinum capsule the organic matter was consumed, giving out a smell of burnt horn, leaving 0.425 gr. of fixed residuum. The composition of the soluble portion was found to be as follows, viz:

| | |
|---|---|
| Organic and volatile matters, | 0.530 |
| Carbonate of lime, | .127 |
| Carbonate of magnesia, | .181 |
| Carbonate of manganese, trace. | |
| Potash, | .096 |
| Soda, | .054 |

One hundred grains of the air-dried soil gave up 2.44 grains of *moisture*, when dried at 320° F. Its composition, thus dried, was found to be as follows, viz:

| | |
|---|---|
| Organic and volatile matters, | 4,120 |
| Carbonate of lime, | .134 |
| Carbonate of magnesia, | .280 |
| Carbonate of manganese, | .081 |
| Alumina, oxide of iron, and trace of phosphates, | 4.850 |
| Potash, | .139 |
| Soda, | .063 |
| Silica and insoluble silicates, | 89.650 |
| Loss, | .683 |
| | 100.000 |

No. 3—LIGNITE. *Labeled "Lignite, bluff of Fort Jefferson, Ballard county, Ky."*

A dull brownish-black friable substance, full of irregular cracks or fissures, which appear to have been produced by shrinkage or drying; quite absorbant of moisture, adhering slightly to the tongue; fresh fracture, presenting a dull pitch-like lustre in some of the layers, approaching, in some parts, the lustre of coal. Over the spirit lamp, on platinum foil, it burnt at first with a smokey flame, somewhat like coal, but with the odor of peat; it continues to burn like punk or rotten wood, when removed from the flame, until it is reduced to a bulky ash.

Its specific gravity is, - - - - - - 1.219

Composition, dried at the ordinary temperature—

| | | | |
|---|---|---|---|
| Moisture, | 13.20 | Total volatile matters, | 50.60 |
| Volatile combustible matters, | 37.40 | | |
| Carbon, | 38.10 | Black residuum, | 49.40 |
| Ashes, (buff-colored,) | 11.30 | | |
| | 100.00 | | 100.00 |

Its composition, when thoroughly dried at 212°, may be stated as follows, viz:

| | |
|---|---|
| Volatile combustible matters, | 43.088 |
| Fixed carbon, | 43.894 |
| Ashes, | 13.018 |

The buff-colored ashes were found to contain a trace of phosphoric acid, and notable quantities of oxide of iron, alumina, and lime.

No. 4—CLAY. *Labeled "Potters' clay, four miles south of Blandville, Ballard county, Kentucky; Mr. Samuel's farm."*

Color, light yellowish-grey; exhibits minute spangles of mica before the lens; heated before the blowpipe becomes first dark-colored then burns white.

Composition, dried at 212°—

| | |
|---|---|
| Silica, | 71.94 |
| Alumina, with a trace of oxide of iron, | 20.70 |
| Lime, | .37 |
| Magnesia, | .35 |
| Potash, | .63 |
| Water, with a trace of organic matter, | 6.20 |
| | 100.19 |

This was examined for the general ingredients by fusion with mixed carbonates of soda and potash, &c., and for the alkalies by fusion with carbonate of lime and chloride of ammonium.

## BATH COUNTY.

No. 5—Limonite. *Iron ore from Messrs. Robert & A. G. Carter's furnace, Bath county, Kentucky, five miles beyond the Olympian Springs, adjoining the White Sulphur Springs; (fourteen miles from Owingsville and fifty-three miles from Lexington.)*

Ore beds described to be from eight to twelve inches thick, on a basis of limestone, covered by blue clay and fire clay.

Ore, a compact, hard, apparently pure hæmatite; powder of a dark, brownish, red color.

Specific gravity, - - - - - - - 3.266

Composition, dried at 212° F—

| | | |
|---|---|---|
| Oxide of iron, (peroxide,) | 79.90 | 55.95 per cent. of *Iron*. |
| Oxide of manganese, | 1.80 | |
| Alumina, | 1.10 | |
| Carbonate of lime, | 0.10 | |
| Carbonate of magnesia, | 1.53 | |
| Silex and insoluble silicates, | 9.00 | |
| Water and loss, | 6.57 | |
| | 100.00 | |

The air-dried ore lost 3.1 per cent. of hygrometric *moisture* when dried at 212°.

No. 6—Coal. *From the same locality as the preceding. Reported to be in beds four feet thick, or in two beds, each of two feet, separated by two feet of black shale.*

A *splint coal;* cleaving in rather thin lays, separated by fibrous carbonaceous matter, (fibrous coal;) cross fracture of a pitch black color and lustre; fissures and edges of the layers coated with ochreous oxide of iron. The fibrous matter presented the appearance of vegetable impressions, and is to some extent infiltrated with pyrites.

Specific gravity, - - - - - - - 1.321

Heated on platinum foil over the spirit lamp, it swelled up somewhat, but did not soften very much; does not appear to be a good *coking* coal.

Composition dried at 212°—

| | | |
|---|---|---|
| Volatile combustible matters, | 38.00 | |
| Carbon in the coke, - - | 53.90 | Coke, 62. per cent. |
| Ashes, (light grey color,) - | 8.10 | |
| | 100.00 | |

The recent coal lost three per cent. of moisture when dried at 212°. The ashes contain a small proportion of sulphate of lime.

By a separate process the total per centage of *sulphur* in this coal was found to be about 0.99.

The locality from whence these two minerals are obtained is described as an outlier of the coal formations.

### BUTLER COUNTY.

### No. 7—Grey Carbonate of Iron. *Labeled "Carbonate of iron, shale bank, Alum Spring, Butler county, Kentucky."*

A hard, compact mineral, of a dark grey color; streak, light grey; fracture, flat-conchoidal; structure, fine granular. Outer surface, to the thickness of about one-sixteenth of an inch, reddish-yellow from the per-oxidation of the iron.

Specific gravity, - - - - - - - 3.490

Composition, dried at 212° F.—

| | | |
|---|---|---|
| Carbonate of iron, - - | 65.96 | 36.90 per cent. Iron. |
| Peroxide of iron, - - | 7.19 | |
| Carbonate of lime, - - | 5.90 | |
| Carbonate of magnesia, - | 6.03 | |
| Carbonate of manganese, - | 1.57 | |
| Phosphoric acid, - - | 2.64 | |
| Potash, - - - - - | .23 | |
| Soda, - - - - - | .06 | |
| Bituminous matter, - - | 1.03 | |
| Silex and insoluble silicates, | 8.70 | |
| Water and loss, - - - | .69 | |
| | 100.00 | |

The air-dried ore lost 0.8 per cent. of *moisture* when dried at 212° F.

No. 8—Coal. *Labeled "Tygert's coal bank, on the waters of Hickory Camp creek, Butler county, Kentucky."*

A friable, pitch-black coal; fissures stained with ochreous oxide of iron; charcoal-like fibrous coal between the layers.

Specific gravity, - - - - - - - 1.291

Composition, dried at the ordinary temperature—

| | | | |
|---|---|---|---|
| Moisture, | 7.20 | Total volatile matters, | 38.60 |
| Volatile combustible matters, | 31.40 | | |
| Carbon in the coke, | 56.90 | Coke, (moderately light,) | 61.40 |
| Ashes, (light yellowish grey,) | 4.50 | | |
| | 100.00 | | 100.00 |

Composition, dried at 212°—

| | |
|---|---|
| Volatile combustible matters, | 33.84 |
| Carbon in the coke, | 61.27 |
| Ashes, | 4.89 |
| | 100.00 |

*Sulphur* is found in it in the proportion of 0.29 per cent. The ashes contain no appreciable quantity of sulphate of lime.

Heated over the spirit lamp, on platinum foil, it swelled up and softened considerably, leaving a cellular coke. It appears to be a pretty good coking coal.

A singular fact was observed in relation to this coal, which, however, may possibly be accidental, as the experiment was not repeated. Some of the coal in very fine powder, folded in paper, placed in the sand-bath at the temperature of about 400° F., took fire spontaneously.

No. 9—Coal. *Labeled, "Pardon Sheldon's coal, head waters of Welch creek, Butler county, Kentucky."*

A very pure looking, soft coal, of a pitchy-black color and strong lustre, not soiling the fingers; presenting no appearance of fibrous coal, nor of pyritous or other impurities.

Specific gravity, - - - - - - - - 1.247

Heated over the spirit lamp, on platinum foil, it softened and swelled up a good deal—the volatile matter burning off with a very smoky flame, leaving a light spongy coke. It appears to be a good coking coal.

Composition, dried at the ordinary temperature—

| | | | |
|---|---|---|---|
| Moisture, | 4.00 | Total volatile matters, | 38.70 |
| Volatile combustible matters, | 34.70 | | |
| Carbon in the coke, | 60.70 | Coke, (light, spongy,) | 61.30 |
| Ashes, (dirty salmon color,) | .60 | | |
| | 100.00 | | 100.00 |

Composition, dried at 212° F.—

| | |
|---|---|
| Volatile combustible matters, | 36.146 |
| Carbon in the coke, | 63.229 |
| Ashes, | .625 |
| | 100.000 |

The total per centage of *sulphur* is 0.268. The salmon-colored ashes contain only a small trace of sulphate of lime. This coal is remarkable for the very small amount of ashes which it leaves.

No. 10—SOIL. *Labeled "Soil and sub-soil, four miles south of Rochester—ridge land—Butler county, Kentucky."*

The dry soil is of a dirty buff color. Washed with water it left more than 47. per cent. of very *fine sand*, containing a few larger rounded grains of silicious mineral.

One thousand grains, treated, as before described, with water charged with carbonic acid gas, gave up 1.884 grains of *solid matter*, dried at 212° F. This *extract*, treated with pure water, left of *insoluble matter*, which had been dissolved by the carbonic acid, 0.837; the composition of which is as follows, viz:

| | |
|---|---|
| Silica, | 0.190 |
| Carbonate of lime, | .077 |
| Carbonate of magnesia, | .503 |
| Alumina, oxide of iron and trace of phosphates, | .067 |

The portion which was dissolved by the water weighed, when dried at 212° F., 1.047 grains. Ignited in a platinum capsule, there were burnt out of it, with a smell of burning animal matter,

| | |
|---|---|
| Organic and volatile substances, | 0.600 |
| The residue consisted of | |
| Carbonate of lime, | .167 |
| Carbonate of magnesia, | .140 |
| Carbonate of manganese, | .042 |
| Potash, | .082 |
| Soda, | .013 |

Also, a slight trace of alumina and phosphates.

One hundred grains of the soil dried at 320° Fah., when analyzed by the usual mode gave the following results, viz:

| | |
|---|---|
| Organic and volatile matters, | 3.460 |
| Carbonate of lime, | .097 |
| Carbonate of magnesia, | .305 |
| Carbonate of manganese, | .025 |
| Potash, | .204 |
| Soda, | .074 |
| Alumina, oxide of iron and trace of phosphates, | 5.030 |
| Silica and insoluble silicates, | 90.590 |
| Loss, | .215 |
| | 100.000 |

This soil contains very nearly as much potash as the rich soil of Fayette county, but does not yield as large a proportion of the phosphates.

### CARTER COUNTY.

No. 11—Iron ore. *Labeled "Mr. Wallace's iron ore, near falls of Blain, Carter* county, Kentucky."*

A dark reddish-brown mineral, with interspersed spots of dull yellowish; appearance generally dull, but slightly glimmering, like spar, in the yellowish portions. Powder of a brownish-buff color.

Specific gravity, - - - - - - - 2.731

Composition, dried at 212° F.—

| | | |
|---|---|---|
| Oxide of iron, | 23.20 | 19.24 per cent. of *Iron.* |
| Carbonate of iron, | 6.28 | |
| Carbonate of lime, | 51.35 | |
| Carbonate of magnesia, | 1.53 | |
| Carbonate of manganese, | 3.41 | |
| Alumina, | 1.95 | |
| Phosphoric acid, | .24 | |
| Potash, | .23 | |
| Soda, | .18 | |
| Silica and insoluble silicates, | 9.67 | |
| Water and loss, | 1.96 | |
| | 100.00 | |

The air-dried ore lost 1. per cent. of *moisture* when dried at 212°. Containing a large proportion of carbonate of lime, and a small amount of alumina, this mineral may be valuable to flux, in the furnace, with ores containing too large a proportion of aluminous or silicious matter.

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* This ore was inadvertently labeled Carter county; it should have been Lawrence county.

By itself it would not give good results, because of its small relative quantity of iron, and large excess of lime.

No. 12—LIMONITE. *Labeled "Ore from Tygert's, Carter county, Kentucky, on the sub-carboniferous limestone."*

A dark reddish-brown mineral; dirty ochreous on the exterior; adhering to the tongue. Powder dirty yellowish-brown color.

|  |  |  |
|---|---|---|
| Specific gravity, |  | 3.256 |
| Composition, dried at 212° F.— |  |  |
| Peroxide of iron, | 71.50 | — 50.07 per cent. of *Iron*. |
| Alumina, | 2.45 |  |
| Magnesia, | 1.03 |  |
| Brown oxide of manganese, | 1.37 |  |
| Potash, | .34 |  |
| Soda, | .12 |  |
| Silica and insoluble silicates, | 11.97 |  |
| Combined water, | 11.59 |  |
|  | 100.37 |  |

The air-dried ore lost 1.7 per cent. of *moisture* when dried at 212°.

No. 13—LIMONITE. *Labeled "Best ore, Sandy furnace, Carter county, Kentucky."*

A dark reddish-brown ore, in irregular layers, separated by soft yellow ochreous mineral. Powder of a brownish-yellow color.

|  |  |  |
|---|---|---|
| Composition, dried at 212° F.— |  |  |
| Peroxide of iron, | 67.40 | — 42.20 per cent. of *Iron*. |
| Alumina, | .87 |  |
| Carbonate of lime, | .57 |  |
| Magnesia, | 1.80 |  |
| Brown oxide of manganese, | .95 |  |
| Potash, | .50 |  |
| Soda, | .16 |  |
| Silica, and insoluble silicates, | 17.57 |  |
| Combined water, | 11.56 |  |
|  | 101.38 |  |

The air-dried ore lost 2.2 per cent. of moisture when dried at 212°.

These two are very rich and valuable ores, requiring, however, the use of lime to flux them in the furnace, which may, perhaps, be profitably substituted by the use of the next described mineral, in proper proportions.

No. 14—FERRUGINOUS LIMESTONE. *Labeled "Green Rock, which cuts out the ore, Sandy Furnace, Carter county, Ky."*

A dull looking bluish-grey-green rock, mottled with lighter green and dirty yellowish-brown; small spangles of mica and specks of spar visible under the lens; as hard as ordinary limestone; powder of a greenish-grey color.

Specific gravity, - - - - - - - - - 2.809

Composition, dried at 212° F.—

| | | |
|---|---|---|
| Carbonate of iron, - - - | 14.26 | = 18.55 per cent. of *Iron*. |
| Oxide of iron, - - - | 16.77 | |
| Carbonate of lime, - - - | 35.15 | |
| Carbonate of magnesia, - - | 6.54 | |
| Carbonate of manganese, - | .84 | |
| Alumina, - - - - - | 5.85 | |
| Potash, - - - - - - | .29 | |
| Soda, - - - - - - | .08 | |
| Silica and insoluble silicates, - | 19.17 | |
| Water and loss, - - - | 1.05 | |
| | 100.00 | |

No. 15—COAL. *Labeled "Kilgore's Coal, Williams' creek, on the Lexington and Big Sandy railroad—fourteen miles from Ashland—Carter county, Ky."*

A pure looking splint coal, having a lamellar fracture, with vegetable impressions between the layers, not in the form of fibrous coal, but smooth and hard, not soiling the fingers; cross-fracture pitch-black. lustrous; no appearance of pyrites or other impurities; heated over the spirit lamp it swelled up somewhat, but did not soften much.

Specific gravity, - - - - - - - - - 1.313

Composition, dried at the ordinary temperature—

| | | | |
|---|---|---|---|
| Moisture, - - - - | 5.40 | Total volatile matters | [illegible] |
| Volatile combustible matters, - | 35.60 | | |
| Carbon in the coke, - - - | 55.00 | Coke, (pretty dense | [illegible] |
| Ashes, (pale grey,) - - - | 4.00 | | |
| | 100.00 | | [illegible] |

Composition, dried at 212° F.—

| | |
|---|---|
| Volatile combustible matters, - - - - - | [illegible] |
| Carbon in the coke, - - - - - - | [illegible] |
| Ashes, - - - - - - - - | [illegible] |
| | [illegible] |

Sulphur was found in this coal in the proportion of 0.716 per cent. The ashes contained no sulphate of lime.

### No. 16—COAL. *Labeled "Cannel Coal from Barrett's creek, Carter county, Ky., six miles north-west of Grayson."*

A dull looking coal, with a slaty structure, not soiling the fingers; not very easily broken; exterior stained with oxide of iron; fracture across the laminæ of a dull, jet-like lustre; the surfaces of the layers as dull as black slate. Heated over the spirit lamp it decrepitated strongly, burnt at first with a smoky flame; did not swell up or change its form.

Specific gravity, - - - - - - - - 1.443

Composition, dried at the ordinary temperature—

| | | | |
|---|---|---|---|
| Moisture, - - - - | 4.00 | Total volatile matters, - | 37.50 |
| Volatile combustible matters, - | 33.50 | | |
| Carbon in the coke, - - - | 42.70 | Dense coke, - - - | 62.50 |
| Ashes, (dark lilac color,) - - | 19.80 | | |
| | 100.00 | | 100.00 |

Composition, dried at 212° F.—

| | |
|---|---|
| Volatile combustible matters, - - - - - | 34.896 |
| Carbon in the coke, - - - - - - | 44.478 |
| Ashes, - - - - - - - - - | 20.626 |
| | 100.000 |

*Sulphur* was found in it in the proportion of 7.905 per cent. The value of this coal is greatly injured by its very large proportion of ashes and of sulphur. The ashes contained no perceptible amount of sulphate of lime.

### No. 17—COAL. *Labeled "Gallion's Coal, Williams' creek, on the Lexington and Big Sandy railroad, eighteen miles from Ashland, in Carter county, Ky."*

A very pure looking coal, of a pitch-black color, and strong lustre; not soiling the fingers; moderately hard; very little fibrous coal, with vegetable impressions between the layers, and but little appearance of pyritous matter. Heated over the spirit lamp it decrepitated, softened very much and swelled up; it is probably a coking coal.

Specific gravity, - - - - - - - - 1.312

Composition, dried at the ordinary temperature—

| | | | |
|---|---|---|---|
| Moisture, | 5.00 | Total volatile matters, | 45.80 |
| Volatile combustible matters, | 40.80 | | |
| Carbon in the coke, | 49.50 | Moderately dense coke, | 54.20 |
| Ashes, (dark lilac color,) | 4.70 | | |
| | 100.00 | | 100.00 |

Composition, dried at 212°—

| | |
|---|---|
| Volatile combustible matters, | 42.947 |
| Carbon in the coke, | 52.105 |
| Ashes, | 4.948 |
| | 100.00 |

*Sulphur* was found in it in the proportion of 2.410 per cent. The ashes contained only a trace of sulphate of lime.

This coal would be more valuable for manufacturing purposes did it contain less sulphur. It is possible, however, that the specimen examined presented more than the average proportion of pyrites—this injurious ingredient of coals being generally very irregularly diffused.

### CHRISTIAN COUNTY.

No. 18—COAL. *Labeled "Keath's Coal, near Pond river, north-east part of Christian county, Ky."*

A soft friable coal, not soiling the fingers; of a dull pitch-black appearance; seems to be free from pyrites or earthy impurities. Small fragments heated over the spirit lamp softened, swelled up, and agglutinated into a light spongy coke. Appears to be a good coking coal.

Specific gravity, - - - - - - - - 1.307

Composition, dried at the ordinary temperature—

| | | | |
|---|---|---|---|
| Moisture, | 2.80 | Total volatile matters, | 43.90 |
| Volatile combustible matters, | 41.10 | | |
| Carbon in the coke, | 48.90 | Coke, | 56.10 |
| Ashes, (pale reddish-grey, | 7.20 | | |
| | 100.00 | | 100.00 |

Composition, dried at 212°—

| | |
|---|---|
| Volatile combustible matters, | 42,284 |
| Carbon in the coke, | 50.309 |
| Ashes, | 7.407 |
| | 100.000 |

*Sulphur* was found in this coal in the proportion of 2.16 per cent. The ashes contained 0.100 per cent. of sulphate of lime. Dried at 212° the air-dried coal lost 2.8 per cent. of moisture.

No. 19—COAL. *Labeled "(Lacey's) Atchison's Coal, McFarland's branch of the west fork of Pond river, north-east part of Christian county, Ky."*

A soft bituminous coal, of a pitch-black color; considerable lustre. Some fibrous coal, exhibiting vegetable impressions, between the layers. Fragments heated over the spirit lamp softened, swelled moderately, and agglutinated into a spongy coke.

Specific gravity, - - - - - - - - 1.278

Composition, dried at ordinary temperature—

| | | | |
|---|---|---|---|
| Moisture, - - - - | 4.00 | Total volatile matters, - | 41.70 |
| Volatile combustible matters, - | 37.70 | | |
| Carbon in the coke, - - | 53.30 | Coke, (bright, spongy,) | 58.30 |
| Ashes, (lilac colored,) - - | 5.00 | | |
| | 100.00 | | 100.00 |

Composition, dried at 212°—

| | |
|---|---|
| Volatile combustible matters, - - - - | 39.271 |
| Carbon in the coke, - - - - - | 55.520 |
| Ashes, - - - - - - - - - | 5.209 |
| | 100.000 |

The total amount of *sulphur* was found to be 1.363 per cent. The ashes contained a small trace of *sulphate of lime.*

No. 20—SOIL. *Labeled "Soil from southern part of Christian county, Ky., between Dr. Quarles' and Oak Grove."*

Color pretty dark greyish-brown. Washed with water it left more than thirty-four per cent. of *very fine sand,* of a dark drab color.

One thousand grains, treated with water containing carbonic acid, yielded 3.822 grains of *solid extract,* dried at 212°, which, when treated with pure water, left of *insoluble matter,* which had been dissolved by the carbonic acid, 2.457 grains, of the following composition, viz:

| | |
|---|---|
| Silica, - - - - - - - - - - - - - | .130 |
| Carbonate of lime, - - - - - - - - - - | .830 |
| Carbonate of magnesia, - - - - - - - - - | .115 |
| Carbonate of manganese, - - - - - - - - - | .642 |
| Alumina, oxide of iron, and trace of phosphates, - - - - | .740 |
| Sulphate of lime, a trace. | |

The *soluble matter*, dissolved by the water, weighed, when dried at 212°, 1.365 grains, out of which was burnt, with the smell of burnt horn,

| | |
|---|---|
| Organic and volatile matters, | .960 |
| The residue contained | |
| Carbonate of lime, | .067 |
| Carbonate of magnesia, | .196 |
| Potash, | .096 |
| Soda, | .046 |

With traces of alumina and phosphates.

One hundred grains of the soil, dried at 300°, analyzed by the ordinary method, after digestion in hydrochloric acid, &c., were found to contain—

| | |
|---|---|
| Organic and volatile matters, | 5.680 |
| Carbonate of lime, | .220 |
| Carbonate of magnesia, | .280 |
| Carbonate of manganese, | .415 |
| Alumina, oxide of iron, and trace of phosphates, | 5.470 |
| Potash, | .154 |
| Soda, | .061 |
| Silica and insoluble silicates, | 87.430 |
| Sulphate of lime and loss, | .290 |
| | 100.000 |

The air-dried soil lost 2.6 per cent. of *moisture*, when dried at 300° F.

### No. 21—MAGNESIAN LIMESTONE. *Labeled "Hydraulic Limestone, near Esquire Lindsey's, Christian county, Ky."*

A dull, rather soft, rock, of a fine granular structure, light drab color; fragments may be broken off and crushed to powder in the fingers, without much difficulty; adheres to the tongue.

Composition, dried at 212°—

| | |
|---|---|
| Carbonate of lime, | 52.20 |
| Carbonate of magnesia, | 37.95 |
| Alumina, oxide of iron, &c., | 2.27 |
| Silica and insoluble silicates, | 6.38 |
| Potash, | .28 |
| Moisture and loss, | .92 |
| | 100.00 |

The carbonates of lime and magnesia are very nearly in equivalent proportions in this limestone. It contains a much smaller proportion of clay than is usually found in hydraulic limestone.

No. 22—**Ferruginous Limestone.** *Labeled "Iron? hill at Keath's, north-east part of Christian county, Ky., near Pond river."*

A compact, fine-grained mineral; general color dark grey, with a slight tinge of green; exterior portion ochreous; dark reddish-brown matter lining the fissures, and extending from exterior to the interior. Powder cinnamon colored, or the color of ground *lapis calaminaris.*

| | |
|---|---|
| Specific gravity, | 2.786 |
| Composition, dried at 212°— | |
| Carbonate of lime, | 65.69 |
| Carbonate of iron, | 8.00 |
| Oxide of iron and alumina, | 13.23 |
| Magnesia, | 1.57 |
| Oxide of manganese, | .34 |
| Silica and insoluble silicates, | 11.37 |
| Alkalies, not estimated. | |
| | 100.20 |

The air-dried ore lost 0.7 per cent. of *moisture,* when dried at 212° F. This mineral contains only about ten or twelve per cent. of iron. It might be useful as a fluxing material, in the smelting of silicious or argillaceous ores, and deserves trial as a water cement.

## CRITTENDEN COUNTY.

No. 23—**Limonite.** *Labeled "Iron Ore from Sneed's mines, on Tradewater river, Crittenden county, Ky." (From Dr. Wm. C. Sneed.)*

Above the coal a compact, dark reddish-brown mineral, mottled, with softer included portions, of an ochreous appearance. Powder of a brownish-yellow color.

| | | |
|---|---|---|
| Specific gravity, | 2.684 | |
| Composition, dried at 212°— | | |
| Peroxide of iron, | 39.60 | = 27.73 per cent. of *Iron.* |
| Alumina, | 1.00 | |
| Brown oxide of manganese, | .20 | |
| Phosphoric acid, | .67 | |
| Lime, | .58 | |
| Magnesia, sulphuric acid, traces. | | |
| Silica and insoluble silicates, | 51.30 | |
| Combined water and loss. | 6.65 | |
| | 100.00 | |

The air-dried mineral lost 0.8 per cent. of *moisture,* when dried at 212 °F.

No. 24—CLAY IRONSTONE. *Labeled "Iron Ore from Sneed's mines, on Tradewater, Crittenden county, Ky."*

Found in a layer six to twelve inches thick, separated by twelve inches of shale from the three and a half feet thick bed of coal below.

A compact dark grey mineral, resembling fine-grained limestone; quite hard; powder of a light grey color.

Specific gravity, - - - - - - - - 3.225

Composition, dried at 212°—

| | | |
|---|---|---|
| Carbonate of iron, - - - | 12.42 | — 15.86 per cent. of *Iron*. |
| Peroxide of iron, - - - | 14.07 | |
| Carbonate of lime, - - - | 18.48 | |
| Carbonate of magnesia, - - | 1.49 | |
| Phosphate of lime, - - - | 29.49 | |
| Alumina, - - - - | 2.91 | |
| Potash, - - - - - - | .57 | |
| Soda, - - - - - - | .15 | |
| Bituminous matter, - - - | 1.32 | |
| Oxide of manganese, a trace. | | |
| Silica and insoluble silicates, - | 16.07 | |
| Water and loss, - - - | 3.03 | |
| | 100.00 | |

This mineral is remarkable for its very large proportion of phosphate of lime, which causes it to contain nearly sixteen and a half per cent. of phosphoric acid, and which must render it useless as an iron ore. For the same reason, and in consequence of the considerable amount of alkalies which it presents, it may possibly be made a valuable mineral manure, if burnt, ground to powder, and applied to land deficient in phosphates and the alkalies.

No. 25—COAL. *Labeled "Specimen of Coal from Sneed's coal mines, on Tradewater, Crittenden county, Ky."*

The bed is described as three feet eight inches in thickness. Seven miles from the Ohio river.

A very black, and apparently very pure, soft bituminous coal, resembling the Pittsburg coal in its external appearance. Some fibrous coal between the layers, exhibiting vegetable impressions, and some little appearance of pyrites. Some fragments heated over the spirit lamp softened and swelled up a good deal, leaving a coke of moderate density.

| | | |
|---|---|---|
| Specific gravity, | | 1.316. |
| Composition, dried at 212° F.— | | |
| Volatile combustible matters, | 37.00 | |
| Carbon in the coke, | 55.40 | Coke 63. per cent. |
| Ashes, (purplish-grey,) | 7.60 | |
| | 100.00 | |

The air-dried coal lost 2. per cent. of moisture when dried at 212°. The total amount of *sulphur* amounts to 1.04 per cent., of which .04 is in sulphate of lime of the ash.

No. 26—SULPHURET OF ZINC. *Labeled "Lead mines, one and a half miles south of Sulphur Springs, on Hurricane creek, Crittenden county, Kentucky."*

A dark brown mineral; drusy, with minute quartz crystals and a little calcareous spar; containing also some galena, (sulphuret of lead;) which substances are mixed throughout the mass. Powder of a dark olive-grey color.

| Composition— | |
|---|---|
| Sulphuret of zinc, | 60.30 |
| Sulphuret of lead, | 2.60 |
| Alumina and oxide of iron, | 10.19 |
| Carbonate of lime, | 3.37 |
| Magnesia, | .20 |
| Silex and insoluble silicates, | 26.38 |
| | 103.04 |

This ore contains more than 40. per cent. of zinc. It contains traces of copper, manganese, and phosphoric acid. If found in large quantities it might be made valuable in the preparation of the zinc white paint, (oxide of zinc,) which is now much used as a substitute for the white lead.

### FAYETTE COUNTY.

No. 27—SOIL. *From a woodland pasture, (land which had never been in cultivation,) about eight miles from Lexington, near Newtown turnpike, head waters of North Elkhorn creek, farm of Mrs. Dallam.*

*Color*, dark greyish-brownish, or chocolate. Washed carefully with water this soil left more than 62. per cent. of *exceedingly fine sand*, somewhat lighter colored than the soil itself. This sand, washed with hydrochloric acid and dried again, weighed about 55. per cent.

This very fine sand, or quartz powder, the presence of which is not generally suspected in our rich loam soil, is so fine as to pass through the finest bolting cloth, of about five thousand apertures to the inch —leaving only about 0.4 of one per cent. of quartzy grains, not as large as small mustard seed.

Dried at 320° F., this soil lost 4.44 per cent. of *moisture*. Its composition, thus dried, was found to be as follows, viz:

| | |
|---|---|
| Organic and volatile matters, | 8.000 |
| Carbonate of lime, | .494 |
| Carbonate of magnesia, | .420 |
| Oxides of iron and manganese, | 6.170 |
| Alumina, | 4.181 |
| Phosphate of lime, | .560 |
| Potash, | .205 |
| Soda, | .062 |
| Silica and insoluble silicates, | 79.910 |
| | 100.000 |

The silicious residue, (79.9 per cent.,) from the action of hydrochloric acid, when examined by the microscope exhibited a large proportion of clear quartzy particles; in which respect, however, it resembled, nearly, the silicious residue of most of the soils examined.

The unusual fertility of this celebrated blue limestone (blue grass) soil is attributable—1. To its state of extreme division. 2. Its large proportion of phosphates and the alkalies. 3. The great amount of organic matter, &c., which it contains. The latter ingredient—the organic matter—gives the soil its dark color, makes it light and very retentive of moisture and gases favorable to vegetable growth; it materially aids in the solution of the mineral elements of vegetable nutrition, and by its own decomposition furnishes directly to plants a rich supply of food.

The *specific gravity* of this soil is 2.443, but in consequence of its great porosity this does not give a correct idea of the weight of a cubic foot of it. A cubic foot of a solid substance having the above mentioned specific gravity would weight more than one hundred and seventy-nine pounds; but by actual experiment—by weighing a portion of this dried soil compressed into a specific gravity bottle—it was found to weigh only at the rate of about seventy-one and a half pounds to the cubic foot, (71.543 pounds.) This gives for the weight of the soil on an acre of ground, (43.560 square feet,) to the depth of one foot only, more than three millions of pounds, (3.116.413$\frac{080}{100}$ pounds.)

Taking this immense quantity of matter into consideration, which really represents, in the case of many plants, not one-half of that from which they draw their nourishment, it must be evident that quantities of valuable nutritious matter, sufficient for the support of vegetable growth, may exist in a soil, and yet may entirely escape the most delicate processes, and be unappreciable, in the quantities generally taken by the chemist for his analyses, by his finest balances.

According to these data, the quantity of potash in this Fayette county soil, taken to the depth of one foot only, is more than six thousand three hundred and eighty-eight pounds—a quantity which seems almost inexhaustible by the most wasteful culture.

That the proportion of the valuable ingredients of the soil is much diminished by its continued cultivation in corn and grain crops is exhibited in the analysis of the next succeeding soil, which was taken from the same locality as this, but which had been for more than fifty years subjected to constant cultivation.

No. 28—Soil. *From an old field long in cultivation; same locality as the last; adjoining field.*

*Color*, light chocolate, or grey-brown. Washed carefully with water this soil left more than 68. per cent of *very fine sand*, of a light snuff color, mixed with a few very small rounded particles of iron ore; and about 0.4 of one per cent. of small rounded quartzy particles, some of which are transparent, some milky, yellow, red, and green; all finer than mustard seed, yet presenting the appearance of microscopic boulders.

Dried at 340° this soil lost 4.58 per cent. of *moisture*. Its composition was found to be as follows, viz:

| | |
|---|---|
| Organic and volatile matters, | 5.980 |
| Carbonate of lime, | .530 |
| Carbonate of magnesia, | .547 |
| Carbonate of manganese, | .204 |
| Phosphate of lime, | .450 |
| Oxide of iron, | 7.190 |
| Alumina, | 4.528 |
| Potash, | .139 |
| Soda, | .031 |
| Silica and insoluble silicates, | 80.430 |
| | 100.029 |

### FULTON COUNTY.

No. 29—SOIL. *Labeled "Soil from Bluffs at Hickman, where milk-sickness is most prevalent, [does it contain more than the ordinary quantity of magnesia?] Fulton county, Ky."*

The dry soil is of a dirty buff color. The air-dried soil lost 1.72 per cent. of *moisture* when dried at 380°. Washed with water it left about 36. per cent. of very *fine sand*. One thousand grains subjected to the action of water containing carbonic acid yielded 1.150 grains of solid matter, dried at 212°. This treated with pure water left 0.85 grains of *insoluble matter*, which had been dissolved by the carbonic acid; having the following composition, viz:

| | |
|---|---|
| Silica, | .140 |
| Carbonate of lime, | .357 |
| Carbonate of magnesia, | .125 |
| Carbonate of manganese, | .085 |
| Alumina, oxide of iron, and traces of phosphates, | .067 |
| Loss, | .076 |

The portion dissolved by the water weighing, when dried at 212°, 0.3 of a grain, was ignited, when it lost of

| | |
|---|---|
| Organic and volatile matter, | 0.100 |
| The residue gave— | |
| Carbonate of lime, | .007 |
| Carbonate of magnesia, | .021 |
| Carbonate of manganese and loss, | .092 |
| Potash, | .060 |
| Soda, | .020 |

The composition of this soil, dried at 380° F., was found to be as follows, viz:

| | |
|---|---|
| Organic and volatile matters, | 1.720 |
| Carbonate of lime, | 1.540 |
| Carbonate of magnesia, | .517 |
| Brown oxide of manganese, | .036 |
| Alumina, oxide of iron, and traces of phosphates, | 4.470 |
| Potash, | .108 |
| Soda, | .052 |
| Silica and insoluble silicates, | 92.350 |
| | 100.793 |

Nothing remarkable, in the mineral ingredients of this soil, appears, to account for the peculiar sickness prevalent in the region from whence it came.

No. 30—Soil. *Labeled "Soil under the gravel bed at Hickman, Fulton county, Ky."*

Color of the dried soil brownish-buff. Washed with water it left about fifty-six per cent. of very *fine sand,* containing a few spangles of mica. The air-dried soil lost 3.8 per cent. of moisture, when dried at 300° F.

One thousand grains treated with water containing carbonic acid gave up 1.275 grains of solid matter, dried at 212° F.; this, treated with pure water, left 1.043 grains of insoluble matter, which had been extracted by the carbonic acid, which had the following composition, viz:

| | |
|---|---|
| Silica, | .190 |
| Carbonate of lime, | .527 |
| Carbonate of manganese, | .269 |
| Sulphate of lime and loss, | .057 |

The *soluble portion,* which weighed 0.232 gr., yielded the following ingredients, viz:

| | |
|---|---|
| Organic and volatile matters, | .100 |
| Carbonate of lime, a trace. | |
| Carbonate of magnesia, | .048 |
| Potash, | .043 |
| Soda, | .041 |

Submitted to general analysis, dried at 300°, this soil yielded the following results, viz:

| | |
|---|---|
| Organic and volatile matters, | 2.600 |
| Carbonate of lime, | .393 |
| Carbonate of magnesia, | .503 |
| Alumina, oxide of iron, and trace of phosphates, | 9.510 |
| Potash, | .170 |
| Soda, | .080 |
| Silica and insoluble silicates, | 87.030 |
| | 100.386 |

### GREENUP COUNTY.

No. 31—Limonite. *Labeled "Block ore, best quality, over the coal and under the hearth sandstone, eight inches thick, Pennsylvania Furnace, Greenup county, Ky."*

A pretty pure limonite; harder portions of a dried blood-brown color; softer parts ochreous, yellow, and reddish. Powder of a brownish-yellow color.

Specific gravity, - - - - - - - 2.918

Composition, dried at 212° F.—

| | | |
|---|---|---|
| Oxide of iron, - - - | 41.70 | = 29.20 per cent of *Iron*. |
| Phosphate of alumina, - | 1.25 | |
| Phosphoric acid, - | 2.30 | |
| Brown oxide of manganese, | .58 | |
| Magnesia, - - - - | .20 | |
| Potash, - - - - | .13 | |
| Combined water, - - | 8.01 | |
| Silex and insoluble silicates, | 45.05 | |
| Loss, - - - - - | .78 | |
| | 100.00 | |

The air-dried ore lost 1.4 per cent. of *moisture*, when dried at 212° F.

No. 32—Limonite. *Labeled "Little Block Ore, average four inches, immediately under the hearth sandstone, Pennsylvania Furnace, Greenup county, Ky."*

A compact limonite of a reddish-brown color; some minute spangles of mica throughout it. Powder of a light reddish-brown color.

Specific gravity, - - - - - - - 2.978

Composition, dried at 212° F—

| | | |
|---|---|---|
| Oxide of iron, - - - | 49.69 | = 34.79 per cent. of *Iron*. |
| Alumina, - - - - | 2.53 | |
| Phosphoric acid, - - - | .22 | |
| Oxide of manganese, - - | .45 | |
| Magnesia, - - - - | .33 | |
| Potash, - - - - - | .38 | |
| Soda, - - - - - | .11 | |
| Combined water, - - | 7.68 | |
| Silica and insoluble silicates, | 38.35 | |
| Loss, - - - - - | .26 | |
| | 100.00 | |

The air-dried ore lost 1.2 per cent. of moisture when dried at 212°.

No. 33—Limonite. *Labeled "Limestone Ore, over limestone, eighteen inches, Pennsylvania Furnace, Greenup county, Ky."*

A pretty compact limonite; portions dense, and dark reddish-brown, others ochreous, bright red; small crystals and geodes of carbonate of lime diffused throughout it. Powder dirty orange-red color.

| | | |
|---|---|---|
| Specific gravity, | | 3.052 |
| Composition dried at 212°— | | |
| Oxide of iron, | 60.00 | = 42.00 per cent of *Iron*. |
| Carbonate of lime, | 20.67 | |
| Carbonate of magnesia, | 3.84 | |
| Alumina, | .68 | |
| Potash, | .17 | |
| Soda, | .06 | |
| Combined water, | 4.07 | |
| Silica and insoluble silicates, | 10.70 | |
| | 100.19 | |

The air-dried ore lost two per cent of *moisture* when dried at 212° F. This ore is remarkable from its large proportion of carbonate of lime, making it valuable to mix with more silicious ores, like the preceding, for the purpose of fluxing.

No. 34—LIMONITE. *Labeled "Limestone Ore over the limestone, Pennsylvania Furnace, Greenup county, Ky."*

A dense and hard limonite; generally of a dark reddish-brown, or dried blood color; ochreous, reddish and yellowish, between the layers; portions somewhat cellular; some minute spangles of mica, and microscopical crystals, probably of calcareous spar. Powder of brownish-yellow ochre color.

| | | |
|---|---|---|
| Specific gravity, | | 3.105 |
| Composition, dried at 212°— | | |
| Oxide of iron, | 72.70 | = 50.91 per cent. of *Iron*. |
| Alumina, | 2.00 | |
| Brown oxide of manganese, | .57 | |
| Magnesia, | .37 | |
| Potash, | .42 | |
| Soda, | .17 | |
| Combined water, | 11.48 | |
| Silica and insoluble silicates, | 13.17 | |
| | 100.88 | |

The air-dried ore lost 1.6 per cent. of *moisture* when dried at 212°.

No. 35—LIMONITE. *Labeled "Top hill ore, average eight inches (four inches to one foot) thick, Pennsylvania Furnace, Greenup county, Ky."*

A dull earthy looking, brown and reddish-brown ore; adheres to the tongue; presenting striæ of different shades of color; outer portions dirty olive-grey; more dense interior part dark reddish-brown. Powder of a dull, dark, brick color.

Specific gravity, - - - - - - - - 3.011

Composition, dried at 212° F.—

| | | |
|---|---|---|
| Oxide of iron, | 54.60 | = 38.23 per cent. of *Iron*. |
| Carbonate of lime, | 13.85 | |
| Phosphate of alumina, | 4.55 | |
| Phosphoric acid, | .74 | |
| Magnesia, | 2.79 | |
| Potash, | .36 | |
| Soda, | .32 | |
| Combined water, | 9.28 | |
| Silica and insoluble silicates, | 13.37 | |
| Loss, | .14 | |
| | 100.00 | |

The air-dried ore lost two per cent. of *moisture*, when dried at 212° F.

No. 36—LIMONITE. *Labeled "Better quality of Impracticable Ore, Pennsylvania Furnace, Greenup county, Ky."*

A dark reddish-brown ore; porous; adhering to the tongue; fine granular, or somewhat fine oolitic, with small angular grains in parts. Powder of a dark reddish-brown color, like "Spanish Brown."

Specific gravity ?

Composition, dried at 212° F.—

| | | |
|---|---|---|
| Oxide of iron, | 87.00 | = 60.90 per cent. of *Iron*. |
| Alumina, | .60 | |
| Phosphoric acid, | .68 | |
| Brown oxide of manganese, | .65 | |
| Magnesia, | .82 | |
| Potash, | .30 | |
| Soda, | .21 | |
| Sulphur, a trace. | | |
| Combined water, | 6.59 | |
| Silica and insoluble silicates, | 3.47 | |
| | 100.32 | |

The air-dried ore lost three per cent. of *moisture*, when dried at 212° F.

This specimen was examined with great care, by a variety of processes, to detect the presence of injurious ingredients, and none are found in it in objectionable quantities.

The true reason of the difficulty experienced in the smelting of this ore is in its *very purity;* in the large amount of oxide of iron which it contains; in the absence of lime, and the small proportion of the materials which fuse together to form the *slag* or *cinder;* without a sufficient quantity of which, in the iron furnace, the reduced iron is not protected from the oxydating influence of the blast. This ore could easily be worked into good iron by mixing it with a proper proportion of earthy (silicious and aluminous) materials, and of limestone, or by using it with ores which are less rich in oxide of iron.

No. 37—CARBONATE OF IRON. *Labeled "Impracticable hard Limestone Ore, four feet thick over the limestone, Pennsylvania Furnace, in Greenup county, Ky."*

Fresh fracture, dark reddish-brown; exterior, silver-grey, from the presence of a whitish incrustation or cement, between the fine crystalline grains of which the mineral is mainly composed, and which give it a somewhat sparkling appearance, like a fine-grained impure coccolite. Some of the grains are reddish, and apparently translucent, but they are generally of a dried blood-brown color, and opaque, imbedded in the white cementing material. *Powder* of a lilac grey color; that of portions inclined to buff.

Composition, dried at 212° F.—

| | | |
|---|---|---|
| Carbonate of iron, | 72.86 | 39.42 per cent. of *Iron.* |
| Oxide of iron, | 7.42 | |
| Carbonate of lime, | 3.17 | |
| Carbonate of magnesia, | 2.80 | |
| Carbonate of manganese, | 1.18 | |
| Phosphoric acid, | .04 | |
| Sulphur, | .15 | |
| Alumina, | 1.97 | |
| Potash, | .32 | |
| Soda, | .10 | |
| Silica and insoluble silicates, | 9.47 | |
| Water and loss, | .52 | |
| | 100.00 | |

The air-dried ore lost 0.7 per cent. of moisture, when dried at 212° F.

This ore would also yield good iron in profitable proportion, if properly fluxed. Like the preceding, it contains rather too small a proportion of the ingredients which make *cinder*. It is probably very fusible into a black slag, when suddenly heated alone in the high furnace.

No. 38—Carbonate of Iron. *Labeled "Impracticable part of Limestone Ore, Pennsylvania Furnace, Greenup county, Ky. (Does it contain sulphur, zinc, arsenic, or other impurities?)"*

Resembles the preceding as to its granular and concretionary characters, but is more sparkling, apparently from the presence of minute spangles of mica. *Powder* of a brownish-buff color.

| | | |
|---|---|---|
| Specific gravity, | | 3.176 |
| Composition, dried at 212° F.— | | |
| Carbonate of iron, | 78.51 | 41.80 per cent. of *Iron.* |
| Oxide of iron, | 5.57 | |
| Carbonate of lime, | 2.36 | |
| Carbonate of magnesia, | 2.81 | |
| Carbonate of manganese, | 1.11 | |
| Alumina, | 1.77 | |
| Phosphoric acid, | .04 | |
| Potash, | .17 | |
| Soda, | .64 | |
| Silica and insoluble silicates, | 4.87 | |
| Sulphur, a mere trace. | | |
| Water and loss, | 2.15 | |
| | 100.00 | |

The air-dried ore lost 0.8 per cent. of *moisture*, when dried at 212° F.

The remarks appended to the preceding ore are equally applicable to this.*

No. 39—Limestone. *Labeled "Limestone used as a flux, Pennsylvania Furnace, Greenup county, Ky."*

A dark grey limestone, pretty compact, sparkling with minute crystalline facets, and containing a few organic remains, the most conspicuous of which, in the small specimen examined, is a portion of a very small encrinal stem.

---

*Other ores were received from this furnace, but the limited time allotted to the chemical investigation prevented their analysis for the present.

| | | |
|---|---|---|
| Specific gravity, - - - - - - - | 2.776 | |
| Composition, dried at 212° F.— | | |
| Carbonate of lime, - - - - - - - - - | | 95.25 |
| Carbonate of magnesia, - - - - - - - | | 2.74 |
| Oxide of iron, alumina, trace of phosphate of lime, - - | | 1.27 |
| Potash, - - - - - - - - - - - | | .09 |
| Soda, - - - - - - - - - - - | | .08 |
| Silica and insoluble silicates, - - - - - - - | | .57 |
| | | 100.000 |

The air-dried rock lost 1. per cent. of *moisture* when dried at 212° F. Quite a pure carbonate of lime; but which, in view of the general richness and purity of the Pennsylvania furnace ores, is not as well suited for use there, as a flux, as a limestone which contains a larger proportion of extraneous ingredients.

No. 40—IRON FURNACE SLAG. *Labeled "Dark purple Slag, produced when making soft grey iron; Pennsylvania Furnace, Greenup co., Ky."*

A glass of a dark, smoky, purple color, when seen through thin edges. Of somewhat difficult fusion before the blow-pipe; in the oxydating flame swelling up and becoming white because of the formation in it of numerous small air bubbles. With soda, gave the manganese re-action; with borax, that of iron. In fine powder, which is white, hydrochloric acid decomposed it perfectly, after digestion in the sand-bath.

| | | | | | |
|---|---|---|---|---|---|
| Specific gravity, - - - - - - - | | | 2.807 | | |
| Composition, dried at 212°— | | | | | |
| Silica, - - - - - - | 55.00 | Containing oxygen, - | | | 28.557 |
| Lime, - - - - - - | 27.10 | " | 7.706 | | |
| Magnesia, - - - - - - | 1.95 | " | .779 | | |
| Protoxide of iron, - - - | 1.57 | " | .348 | | |
| Protoxide of manganese, - - | .27 | " | .060 | | |
| Alumina, - - - - - | 12.30 | " | 5.749 | | |
| Potash, - - - - - - | 1.73 | " | .293 | | |
| Soda and loss, - - - - | .08 | " | .020 | | |
| | 100.00 | | 14.955 | : | 28.557 |
| Oxygen, in the bases and in the silica, nearly as | | - | 1. | : | 1.91 |

The composition of this cinder approaches, very nearly, to what is called a bi-silicate, i. e., a silicate in which the oxygen in the silica is just double that contained in the base, or bases, combined with it. A very trifling addition of limestone would produce a perfect bi-silicate, which is considered the *model cinder* for charcoal furnaces. This, however, is sufficiently near it for all practical purposes.

No. 41—IRON FURNACE SLAG. *Labeled "Pea-green cellular cinder, produced when making strong grey iron of a closer texture than with the dark bottle cinder, but furnace making more iron; Pennsylvania Furnace, Greenup county, Ky."*

A pea-greenish-grey colored slag, full of bubbles of various sizes, from very minute up to the size of an almond kernel. Powder nearly white. Before the blow-pipe, fuses, with some difficulty, into a bottle-green glass.

Composition, dried at 212° F.—

| | | | | |
|---|---|---|---|---|
| Silica, | 60.64 | Containing of oxygen, | | 31.846 |
| Lime, | 14.65 | " | 4.166 | |
| Magnesia, | 2.55 | " | 1.019 | |
| Alumina, | 13.30 | " | 6.217 | |
| Protoxide of iron, | 4.62 | " | 1.025 | |
| Protoxide of manganese, | .88 | " | .198 | |
| Potash, | 2.55 | " | .432 | |
| Soda, | .81 | " | .076 | |
| | 100.00 | | 13.135 : | 31.846 |
| Oxygen nearly as | | | 1. : | 2.42 |

No. 42—PIG-IRON. *Labeled "Pig-iron, Pennsylvania Furnace, Greenup county, Ky."*

A moderately fine-grained grey cast-iron; flattens a little under the hammer, but soon breaks to pieces; yields easily to the file and the cold chisel.

| | | |
|---|---|---|
| Specific gravity, | | 6.770 |
| Composition— | | |
| Iron, | 92.08 | |
| Graphite, | 3.03 | Total carbon, 3.93 |
| Combined carbon, | .90 | |
| Manganese, | .36 | |
| Silicon, | 2.91 | |
| Slag, | .16 | |
| Aluminium, | .07 | |
| Magnesium, | .24 | |
| Potassium, | .12 | |
| Phosphorus, sulphur, and loss, | .13 | |
| | 100.00 | |

No. 43—COAL. *Labeled "Four feet Coal, about twenty feet above the block ore, iucluding one foot of bituminous shale; sixteen inches of coal above the shale; twenty inches of coal below the shale. Pennsylvania Furnace, Greenup county, Ky."*

Rather dull looking coal, breaking readily into laminæ, which are separated by fibrous coal with vegetable impressions, which are generally infiltrated with pyritous matter. Heated over the spirit lamp it decrepitated, softened, and swelled up into a light spongy coke. Appears to be a coking coal.

Specific gravity, - - - - - - - 1.287

Composition, dried at the ordinary temperature—

| | | | |
|---|---|---|---|
| Moisture, - - - - | 6.00 | Total volatile matters, - | 40.20 |
| Volatile combustible matters, - | 34.20 | | |
| Carbon in the coke, - - - | 56.20 | Moderately dense coke, - | 59.80 |
| Ashes, (dark purple-grey,) - | 3.60 | | |
| | | | 100.00 |

Composition, dried at 212°—

| | |
|---|---|
| Volatile combustible matters, - - - - - | 36.383 |
| Carbon in the coke, - - - - - - - | 59.787 |
| Ashes, - - - - - - - - - - | 3.830 |
| | 100.000 |

The per centage of sulphur was found to be 1.694. The ashes contained only a trace of sulphate of lime.

No. 44—LIMONITE. *Labeled "Black vein, twenty feet under the three feet coal; Buena Vista Furnace, Greenup county, Ky."*

A heavy, compact mineral, presenting irregular veins and mottling of a dark grey color, in a dark red-brown mass. Powder of a light snuff-brown color.

Specific gravity, - - - - - - - 3.044

Composition, dried at 212° F.—

| | | |
|---|---|---|
| Oxide of iron, - - - | 61.18 | 46.51 per cent. of *Iron.* |
| Carbonate of iron, - - - | 7.48 | |
| Carbonate of lime, - - - | 2.15 | |
| Carbonate of magnesia, - - | 2.02 | |
| Carbonate of manganese, - | 2.93 | |
| Alumina, - - - - - | 2.27 | |
| Potash, - - - - - - | .45 | |
| Combined water and loss, - | 10.29 | |
| Silica and insoluble silicates, - | 11.23 | |
| Sulphur, a trace. | | |
| | 100.00 | |

The air-dried ore lost 1.7 per cent. of *moisture* when dried at 212°.

No. 45—LIMONITE. *Labeled "Yellow Kidney Ore, thirty feet above the three feet coal, Buena Vista Furnace, Greenup county, Ky."*

Of a dark brown color of various shades; exterior, and some portion of the mass and cavities in the interior, ochreous, yellow, and soft.

Specific gravity, - - - - - - - - 3.132

Composition, dried at 212° F.—

| | | |
|---|---|---|
| Oxide of iron, | 68.10 | = 47.69 per cent. of *Iron*. |
| Alumina, | 2.93 | |
| Phosphoric acid, | .43 | |
| Oxide of manganese, | 1.64 | |
| Magnesia, | .67 | |
| Potash, | .54 | |
| Soda, | .13 | |
| Combined water, | 11.67 | |
| Silica and insoluble silicates, | 13.05 | |
| Carbonic acid and loss, | .84 | |
| | 100.00 | |

The air-dried ore lost 1.5 per cent. of *moisture* when dried at 212° F.

No. 46—LIMONITE. *Labeled "Earthy Kidney Ore, thirty feet over the three feet coal, Buena Vista Furnace, Greenup county, Ky."*

An earthy looking ore, adhering to the tongue; color, varying in layers, from dirty reddish-brown to dirty yellow ochre.

Specific gravity about - - - - - - 3.

Composition, dried at 212° F.—

| | | |
|---|---|---|
| Oxide of iron, | 58.90 | = 41.24 per cent. of *Iron*. |
| Alumina, | 4.15 | |
| Carbonate of lime, | 3.15 | |
| Oxide of manganese, | .97 | |
| Magnesia, | 2.40 | |
| Potash, | .58 | |
| Soda, | .47 | |
| Combined water, | 11.26 | |
| Silica, and insoluble silicates, | 17.87 | |
| Loss, | .25 | |
| | 100.00 | |

The air-dried ore lost 1.3 per cent. of moisture when dried at 212°.

### No. 47—IRON FURNACE SLAG. *Labeled "Dark Glassy Cinder, Buena Vista Furnace, Greenup county, Ky."*

A perfect glass, of a smoky-purplish tint when viewed through the thin edges. Fusing rather more easily than the previously described ones; like No. 64 swells up in the oxidating flame by the formation of numerous air bubbles, which give it a white appearance.

| | | | | | |
|---|---|---|---|---|---|
| Specific gravity, | | | | | —— |
| Composition, dried at 212°— | | | | | |
| Silica, | 56.90 | Containing oxygen, | | | 29.544 |
| Lime, | 13.20 | " | 3.753 | | |
| Magnesia, | 3.46 | " | 1.383 | | |
| Alumina, | 20.50 | " | 9.582 | | |
| Protoxide of iron, | 2.43 | " | .539 | | |
| Protoxide of manganese, | .51 | " | .115 | | |
| Potash, | 3.16 | " | .536 | | |
| Soda, | .36 | " | .092 | | |
| | 100.52 | | 16.000 | : | 29.544 |
| Oxygen nearly as | | | 1. | : | 1.85 |

### No. 48—PIG-IRON. *Labeled "Pig-iron, Buena Vista Furnace, Greenup county, Ky."*

A grey iron of a much finer texture than No. 41; extends somewhat under the hammer, but soon breaks to pieces; yields easily to the file and the cold chisel.

| | | | |
|---|---|---|---|
| Specific gravity, | | | 6.903 |
| Composition— | | | |
| Iron, | 91.88 | | |
| Graphite, | 1.65 | Total carbon, | 5.80 |
| Combined carbon, | 3.15 | | |
| Silicon, | 3.27 | | |
| Manganese, | .35 | | |
| Slag, | .30 | | |
| Aluminium, | .07 | | |
| Traces of phosphorus and sulphur. | | | |
| | 100.67 | | |

### No. 49—CARBONATE OF IRON. *Labeled "Grey Limestone Ore, Bellefonte Furnace, Greenup county, Ky."*

A dark bluish-grey ore; porous; adhering somewhat to the tongue; friable; appearing to be made of small grains, the color of which varies from dark yellowish to black, united by a whitish cement. Powder, light grey color.

Specific gravity, - - - - - - - - ?

Composition, dried at 212° F.—

| | | |
|---|---|---|
| Carbonate of iron, - - - | 62.24 | = 31.93 per cent. of *Iron*. |
| Oxide of iron, - - - | 2.68 | |
| Carbonate of lime, - - - | 2.75 | |
| Carbonate of magnesia, - - | 3.43 | |
| Carbonate of manganese, - | 1.12 | |
| Alumina, - - - - - | 5.15 | |
| Phosphoric acid, - - - - | .54 | |
| Potash, - - - - - - | .44 | |
| Soda, - - - - - - | .15 | |
| Silica and insoluble silicates, - | 18.17 | |
| Water, bitumous water, and loss, | 3.33 | |
| | 100.00 | |

The air-dried ore lost 0.6 per cent. of *moisture* when dried at 212° F. This ore resembles No. 36 in structure and composition, but contains less iron and more silica and alumina, which renders it more manageable in the furnace.

No. 50—CARBONATE OF IRON. *Labeled "Blue Limestone Ore, Bellefonte Furnace, Greenup county, Ky."*

A porous, granular ore; adhering to the tongue; of a dirty buff-grey color. Powder, dirty buff color. (This paper contained another specimen, which seemed to be a limonite—not analyzed.)

Specific gravity, - - - - - - - 3.011

Composition, dried at 212°—

| | | |
|---|---|---|
| Carbonate of iron, - - - | 56.58 | 30.74 per cent of *Iron*. |
| Oxide of iron, - - - | 4.86 | |
| Carbonate of lime, - - - | 2.95 | |
| Carbonate of magnesia, - - | 2.17 | |
| Carbonate of manganese, - | 1.68 | |
| Alumina, - - - - - | .25 | |
| Potash, - - - - - - | .44 | |
| Soda, - - - - - - | .38 | |
| Silica and insoluble silicates, - | 30.10 | |
| Water, trace of phosphoric acid, and loss, - - - - - | .59 | |
| | 100.00 | |

The air-dried ore lost 0.1 per cent. of *moisture* when dried at 212° F.

No. 51—LIMESTONE. *Labeled "Limestone used as a flux at Bellefonte Furnace, when working best, Greenup county, Ky."*

A grey, fine-granular limestone, containing organic remains, (univalve and by-valve shells,) and glimmering with minute crystals of calcareous spar. Powder nearly white.

| | | |
|---|---|---|
| Specific gravity, - - - - - - - - - | 2.687 | |
| Composition, dried at 212°— | | |
| Carbonate of lime, - - - - - - - - - - | | 97.17 |
| Carbonate of magnesia, - - - - - - - - - | | 1.39 |
| Oxide of iron, alumina, and a trace of phosphates, - - - - | | 1.17 |
| Potash, - - - - - - - - - - - - - - | | .11 |
| Soda, - - - - - - - - - - - - - - - | | .09 |
| Silicious residue, - - - - - - - - - - - | | .55 |
| | | 100.00 |

Dried at 212° it lost only 0.4 per cent. of *moisture.*

No. 52—IRON FURNACE SLAG. *Labeled "Cinder, produced at Bellefonte Furnace, when working best, Greenup county, Ky."*

A glassy cinder, of a smoky-purple color when viewed through the thin edges; before the blow-pipe, fused more easily than those previously examined, swelling up and becoming white by the formation of numerous bubbles.

| Composition— | | | | |
|---|---|---|---|---|
| Silica, - - - - - - | 52.20 | Containing oxygen, | | 27.104 |
| Lime, - - - - - - | 17.15 | " | 3.085 | |
| Magnesia, - - - - - | 3.25 | " | 1.299 | |
| Alumina, - - - - - | 23.30 | " | 10.911 | |
| Protoxide of iron, - - - - | .16 | " | .045 | |
| Protoxide of manganese, - - | .27 | " | .061 | |
| Potash, - - - - - - | 2.20 | " | .373 | |
| Soda, - - - - - - - | .91 | " | .283 | |
| Loss, - - - - - - - | .56 | | | |
| | 100.00 | | 16.007 : | 27.104 |
| Oxygen as - - - - - - - - - - | | | 1. : | 1.69 |

No. 53—PIG-IRON. *Labelled "Pig Iron produced from the limestone ore, Bellefonte Furnace, Greenup county, Kentucky."*

Coarser grained than No. 41, and rather darker grey; flattens a little under the hammer, but soon breaks to pieces; yields easily to the file.

Specific gravity, - - - - - - - - 6.915

Composition—

| | | |
|---|---|---|
| Iron, - - - - - - | 94.54 | |
| Graphite, - - - - | 2.25 | Total carbon, - - - 3.33 |
| Combined carbon, - - - | 1.08 | |
| Manganese, - - - - - | .35 | |
| Silicon, - - - - - - | 1.26 | |
| Slag, - - - - - - | .18 | |
| Aluminium, - - - - - | .08 | |
| Potassium, - - - - - | .21 | |
| Sodium, - - - - - - | .03 | |
| Magnesium, - - - - - | .17 | |
| | 100.15 | |

No. 54—Limonite. *Labeled "Main Block Ore; ten to twelve inches thick over the impure ("bastard") limestone, near top of hills, Buffalo Furnace, Greenup county, Kentucky."*

A dark brown, pretty compact limonite, with the appearance of infiltrated calcareous spar throughout it; exterior of the layer earthy, ochreous. Powder of a brownish-yellow ochre color.

Specific gravity, - - - - - - - - 3.124

Composition, dried at 212° F.—

| | | |
|---|---|---|
| Oxide of iron, - - - | 49.45 | = 34.63 per cent. of *Iron*. |
| Carbonate of lime, - - - | 7.35 | |
| Phosphate of alumina, - - | .45 | |
| Magnesia, - - - - - | 2.58 | |
| Oxide of manganese, - - | 1.15 | |
| Phosphoric acid, - - - | 1.53 | |
| Potash, - - - - - - | .69 | |
| Soda, - - - - - - | .19 | |
| Silica and insoluble silicates, - | 25.65 | |
| Water and loss, - - - | 10.96 | |
| | 100.00 | |

The air dried ore lost 1.4 per cent. of *moisture* when dried at 212° F.

No. 45—Limonite. *Labeled "Little Block Ore, over the Main Block, near tops of hills, Buffalo Furnace, Greenup county, Ky."*

A dull looking, reddish-brown ore, porous, adhering to the tongue; presenting the appearance of horizontal stratification; contains a few spangles of mica. Powder of a reddish-iron-rust color.

Specific gravity, - - - - - - - - 3.176

Composition, dried at 212° F.—

| | | |
|---|---|---|
| Oxide of iron, | 66.90 | = 46.85 per cent. of *Iron.* |
| Alumina, | 2.65 | |
| Oxide of manganese, | .65 | |
| Magnesia, | .33 | |
| Phosphoric acid, | .25 | |
| Potash, | .27 | |
| Soda, | .31 | |
| Combined water, | 8.79 | |
| Silica and insoluble silicates, | 19.75 | |
| Loss, | .10 | |
| | 100.00 | |

The air-dried ore lost .2 per cent. of *moisture* when dried at 212°.

No. 56—LIMONITE. *Labeled "Block Kidney Ore, over the Main Block Ore, near tops of hills, Buffalo Furnace, Greenup county, Ky."*

The specimen is a portion of a mass with curved layers of different shades of color, from reddish-brown to yellow-ochre; friable, porous, adhering to the tongue. Powder of a yellowish-brown or snuff color.

Specific gravity, - - - - - - - - 2.845

Composition, dried at 212° F.—

| | | |
|---|---|---|
| Oxide of iron, | 63.50 | = 44.54 per cent. of *Iron.* |
| Alumina, | 3.55 | |
| Oxide of manganese, | 1.95 | |
| Magnesia, | .40 | |
| Potash, | .34 | |
| Soda, | .17 | |
| Combined water, | 12.05 | |
| Silica and insoluble silicates, | 17.95 | |
| Trace of phosphoric acid and loss, | .09 | |
| | 100.00 | |

The air-dried ore lost 1.3 per cent. of *moisture* when dried at 212° F.

No. 57—LIMONITE. *Labeled "Dark brown-red variety of Little Block Ore, over Main Block Ore, Buffalo Ore Banks, Greenup county, Kentucky."*

A dull, reddish-brown porous limonite, adheres to the tongue; contains minute whitish specks. Powder, dark red-brown color.

Specific gravity, - - - - - - - - - 3.120

Composition, dried at 212° F.—

| | | |
|---|---|---|
| Oxide of iron, | 60.50 | = 42.35 per cent. of *Iron*. |
| Oxide of manganese, | 3.15 | |
| Alumina, | 2.95 | |
| Magnesia, | .40 | |
| Potash, | .19 | |
| Soda, | .37 | |
| Combined water, | 6.95 | |
| Silica and insoluble silicates, | 25.35 | |
| Trace of phosphoric and loss, | .14 | |
| | 100.000 | |

The air-dried ore lost 2.2 per cent. of *moisture* when dried at 212° F.

No. 58—LIMONITE. *Labeled "Main Block ore, Buffalo Furnace, over impure (bastard) limestone, tops of hills, Greenup county, Ky."*

Irregular form, concretionary; exterior dirty yellow ochre; interior dark reddish-brown; adheres to the tongue; large porous or cellular; contains small spangles of mica. Powder of a brownish-yellow color.

Composition, dried at 212° F.—

| | | |
|---|---|---|
| Oxide of iron, | 70.30 | = 49.23 per cent. of *Iron*. |
| Alumina, | 2.15 | |
| Magnesia, | .37 | |
| Oxide of manganese, | .75 | |
| Potash, | .17 | |
| Soda, | .16 | |
| Combined water, | 11.76 | |
| Silica and insoluble silicates, | 13.95 | |
| Loss, | .39 | |
| | 100.00 | |

The air-dried ore lost 1.4 per cent. of *moisture* when dried at 212°.

No. 59—LIMONITE. *Labeled "Rough Sandy Block Ore, on the top of the hill near Little Sandy, Macalister or Buffalo ore bank, Greenup county, Kentucky."*

A dirty yellowish-brown ore; granular; porous; adhering firmly to the tongue; sparkling with small scales of mica. Powder, lighter yellowish-brown.

Specific gravity, - - - - - - - - - 3.303

Composition, dried at 212° F.—

| | | |
|---|---|---|
| Oxide of iron, | 63.20 | = 44.26 per cent. of *Iron*. |
| Alumina, | 1.95 | |
| Oxide of manganese, | 1.15 | |
| Magnesia, | .74 | |
| Combined water, | 10.30 | |
| Silica and insoluble silicates, | 22.35 | |
| Phosphoric acid, a trace. | | |
| Potash, | .58 | |
| | 100.13 | |

The air-dried ore lost 1. per cent. of *moisture*, when dried at 212° F.

No. 60—CARBONATE OF IRON. *Labeled "Grey Block Ore, above Main Block Ore, near top of hills, Buffalo Ore Banks, Greenup county, Kentucky."*

Interior portion dark-grey, resembling a limestone, sparkling with confused crystalline plates; on the exterior portion, to the depth of two inches or more, of a dark reddish-brown color. Some appearance of univalve shells. Powder, of interior portion, light yellowish-grey.

Specific gravity, - - - - - - - - - 3.106

Composition, dried at 212° F.—

| | | |
|---|---|---|
| Carbonate of iron, | 46.40 | =28.20 per cent. of *Iron*. |
| Oxide of iron, | 8.28 | |
| Carbonate of lime, | 32.15 | |
| Carbonate of magnesia, | 3.26 | |
| Carbonate of manganese, | 1.24 | |
| Alumina, | .35 | |
| Potash, | .23 | |
| Soda, | .17 | |
| Silica and insoluble silicates, | 2.57 | |
| Water, bituminous matter, and loss, | 5.35 | |
| | 100.00 | |

The air-dried ore lost 0.2 per cent. of *moisture* when dried at 212° F.

No. 61—IMPURE CARBONATE OF IRON. *Labeled "Impure (bastard) Limestone, under the Main Block ore, high up in the hills, Buffalo Furnace, Greenup county, Ky."*

Of a dark grey color; granular, with spots and infiltrations between the grains of dark and greenish; sparkling with minute crystalline plates, as of calcareous spar, and the ends of portions of small encrinal stems. Powder of a light buff color.

Specific gravity, - - - - - - - 2.864

Composition, dried at 212°—

| | | |
|---|---|---|
| Carbonate of iron, | 23.56 | = 11.35 per cent. of *Iron*. |
| Carbonate of lime, | 67.33 | |
| Carbonate of magnesia, | 4.82 | |
| Carbonate of manganese, | .41 | |
| Alumina, | .48 | |
| Potash, | .23 | |
| Soda, | .10 | |
| Silica and insoluble silicates, | 1.99 | |
| Water and trace of phosphoric acid, | 1.08 | |
| | 100.00 | |

The air-dried ore lost only 0.1 per cent. of *moisture* when dried at 212° F. This would doubtless be very useful to mix with more silicious or aluminous ores, for the purpose of fluxing, instead of the pure limestone.

No. 62—LIMESTONE. *Labeled "Limestone used as a flux, Buffalo Furnace, Greenup county, Ky."*

A fine granular limestone, of a light grey color, containing petrefactions.

Specific gravity, - - - - - - - - 2.669

Composition, dried at 212° F.—

| | |
|---|---|
| Carbonate of lime, | 81.55 |
| Carbonate of magnesia, | 2.44 |
| Alumina, oxide of iron, and phosphates, | .35 |
| Potash, | .09 |
| Soda, | .02 |
| Silica and insoluble silicates, | 15.56 |
| | 100.00 |

The air-dried rock lost only 0.1 per cent. of *moisture* when dried at 212°.

No. 63—LIMESTONE. *Labeled "Limestone used as a flux, at Buffalo Furnace, nearly on a level with the Lick Branch of Little Sandy, Greenup county, Ky."*

A greenish-grey, fine granular limestone; between the layers presenting a somewhat marly appearance.

| | | |
|---|---|---|
| Specific gravity, | 2.688 | |
| Composition, dried at 212°— F. | | |
| Carbonate of lime, | | 87.97 |
| Carbonate of magnesia, | | 2.72 |
| Alumina, oxide of iron, &c., | | 1.85 |
| Potash, | | .20 |
| Soda, | | .58 |
| Silica and insoluble silicates, | | 7.15 |
| | | 100.47 |

The air-dried rock lost 0.2 per cent. of *moisture*, when dried at 212° F.

No. 64—IRON FURNACE SLAG. *Labeled "Purple glass cinder, produced at Buffalo Furnace, when making soft iron, Greenup county, Ky."*

A perfectly vitrified slag, of a purple color, transparent in pieces one-fourth of an inch thick; pretty fusible before the blow-pipe; melting into a white globule full of air bubbles.

| Composition— | | | | | |
|---|---|---|---|---|---|
| Silica, | 56.10 | Containing oxygen, | | | 29.13 |
| Lime, | 24.18 | " | 6.87 | | |
| Magnesia, | 1.40 | " | .56 | | |
| Alumina, | 13.90 | " | 6.49 | | |
| Protoxide of iron, | 2.07 | " | .45 | | |
| Protoxide of manganese, | .55 | " | .12 | | |
| Potash, | 2.16 | " | .36 | | |
| Soda, | .39 | " | .10 | | |
| | 100.75 | | 14.95 | : | 29.13 |
| Oxygen as, | | | 1. | : | 1.96 |

No. 65—IRON FURNACE SLAG. *Labeled "Purple compact cinder, produced when making soft grey iron, Buffalo Furnace, Greenup county, Ky."*

Differs but little from the preceding in appearance and properties.

Composition, dried at 212° F.—

| | | | | | |
|---|---|---|---|---|---|
| Silica, | 55.90 | Containing oxygen, | | | 29.02 |
| Lime, | 25.42 | " | 7.23 | | |
| Magnesia, | 1.30 | " | .52 | | |
| Alumina, | 13.40 | " | 6.26 | | |
| Protoxide of iron, | 1.01 | " | .22 | | |
| Protoxide of manganese, | .83 | " | .18 | | |
| Potash, | 1.27 | " | .16 | | |
| Soda, | .63 | " | .23 | | |
| Loss, | .24 | | | | |
| | 100.00 | | 14.80 | : | 29.02 |
| Oxygen nearly as | | | 1. | : | 1.96 |

No. 66—Iron Furnace Slag. *Labeled, "Pea-green cinder, produced when Buffalo Furnace is making much iron, but of a medium closer texture than when purple cinder is formed, Greenup county, Ky."*

A vesicular slag containing fragments of reduced iron; not quite as fusible before the blow-pipe as the two preceding; melting into a compact glass of a rather darker green color.

Composition, dried at 212°—

| | | | | | |
|---|---|---|---|---|---|
| Silica, | 57.90 | Containing oxygen, | | | 30.06 |
| Lime, | 17.56 | " | 4.89 | | |
| Magnesia, | 2.30 | " | 1.00 | | |
| Alumina, | 13.97 | " | 6.53 | | |
| Protoxide of iron, | 6.03 | " | 2.00 | | |
| Protoxide of manganese, | 1.02 | " | .22 | | |
| Potash, | 1.04 | " | .17 | | |
| Soda, | .18 | " | .05 | | |
| | 100.00 | | 14.86 | : | 30.06 |
| Oxygen as, | | | 1. | : | 2.01 |

Lime being rather deficient in proportion in this slag, its place is supplied by protoxide of iron, causing some loss of this metal, and probably producing a less pure iron than when the two preceding "cinders" are formed.

No. 67—Pig-iron. *Labeled "Medium Textured Pig-iron, produced at Buffalo Furnace when making pea-green cinder, and yielding much iron, Greenup county, Ky."*

A rather fine grained, dark grey iron; flattens a little under the hammer, but soon breaks to pieces; yields easily to the file, rather a strong iron.

Specific gravity, - - - - - - 7.086

Composition—

| | | |
|---|---|---|
| Iron, | 93.12 | |
| Graphite, | 3.10 | Total carbon, 3.75 |
| Combined carbon, | .65 | |
| Silicon, | 1.06 | |
| Slag, | .14 | |
| Manganese, | .18 | |
| Aluminium, | .03 | |
| Potassium, | .15 | |
| Phosphorus,, | .70 | |
| Traces of sulphur, magnesia and loss, | .87 | |
| | 100.00 | |

No. 68—PIG-IRON. *Labeled "High White Iron, Buffalo Furnace, Greenup county, Ky."*

A very strong metal; fragments broken from the large piece with great difficulty; small fragments easily crushed under the hammer; hard enough to wear out the best file, to which it scarcely yields; very light colored and fine grained.

Specific gravity, - - - - - - 7.322

Composition—

| | | |
|---|---|---|
| Iron, | 94.70 | |
| Graphite, | 2.20 | Total carbon, 2.95 |
| Combined carbon, | .75 | |
| Silicon, | .60 | |
| Slag, | .26 | |
| Aluminium, | .05 | |
| Potassium, | .14 | |
| Magnesium, | .02 | |
| Phosphorus, | .48 | |
| Traces of manganese, sulphur, and loss, | .80 | |
| | 100.00 | |

A pretty pure iron, containing, however, a little too much phosphorus; a great portion of this might possibly be removed by judicious management in its convertion into bar iron.

No. 69—LIMONITE. *Labeled "Flag Ore, above the limestone, Greenup Furnace, Greenup county, Ky."*

A porous, ochreous looking soft ore, in flat layers, with some portions of reddish and dark reddish brown; adhering firmly to the tongue.

Specific gravity, - - - - - - - 2.681

Composition, dried at 212° F.—

| | | |
|---|---|---|
| Oxide of iron, | 38.50 | = 26.96 per cent. of *Iron*. |
| Alumina, | 3.37 | |
| Magnesia, | 1.20 | |
| Oxide of manganese, | .97 | |
| Potash, | .66 ! | |
| Soda, | .10 | |
| Combined water, | 8.25 | |
| Silica and insoluble silicates, | 46.95 | |
| | 100.00 | |

The air-dried soil lost 1. per cent. of *moisture*, when dried at 212° F. Remarkable for its large proportion of potash. It is *possible*, however, that some fortuitous circumstances caused an over estimate of this ingredient. Our limited time prevented the repetition of the process for the separation of the alkalies.

No. 70—LIMONITE. *Labeled "Big Block Ore, under the limestone, Greenup Furnace, Greenup county, Ky."*

A moderately dense limonite, with irregular layers of rich reddish and yellowish ochreous oxide; the whole containing minute spangles of mica. Powder of a brownish-yellow color.

Specific gravity, - - - - - - - 3.177

Composition, dried at 212° F.—

| | | |
|---|---|---|
| Oxide of iron, | 68.10 | = 47.69 per cent. of *Iron*. |
| Alumina, | 2.17 | |
| Magnesia, | .91 | |
| Oxide of manganese, | .37 | |
| Potash, | .48 | |
| Soda, | .07 | |
| Combined water, | 11.51 | |
| Silica and insoluble silicates, | 16.25 | |
| Loss, | .14 | |
| | 100.00 | |

The air-dried ore lost 1. per cent. of *moisture* when dried at 212° F.

No. 71—LIMONITE. *Labeled "Red Ochre, high up in the hills, Greenup Furnace, Greenup county, Ky."*

A porous, friable ore, of a light red and yellow color, with some admixture of grey. Powder of a light red color.

Composition, dried at 212° F.—

| | | |
|---|---|---|
| Oxide of iron, | 26.60 | = 18.62 per cent. of *Iron*. |
| Alumina, | 2.37 | |
| Magnesia, | .77 | |
| Oxide of manganese, | .17 | |
| Potash, | .34 | |
| Soda, | .17 | |
| Combined water, | 5.68 | |
| Silica and insoluble silicates, | 63.90 | |
| Trace of phosphoric acid. | | |
| | 100.00 | |

The air-dried ore lost 1.6 per cent. of *moisture* when dried at 212° F.

No. 72—LIMONITE. *Labeled "Grey Limestone Ore, but no limestone under it, Greenup Furnace, Greenup county, Ky."*

A dull, granular, and porous ore, adhering to the tongue; some grains of a dark color imbedded in a light colored cement, glimmering with a few minute spangles of mica; color, dark reddish-brown, with gray intermixed. Powder, dirty light reddish brown.

| | | |
|---|---|---|
| Specific gravity, | ? | |

Composition, dried at 212°— F.

| | | |
|---|---|---|
| Oxide of iron, | 51.00 | = 35.71 per cent. of *Iron*. |
| Alumina, | 2.27 | |
| Carbonate of lime, | .47 | |
| Magnesia, | 1.48 | |
| Oxide of manganese, | .97 | |
| Potash, | .52 | |
| Soda, | .28 | |
| Combined water, | 9.81 | |
| Silica and insoluble silicates, | 33.65 | |
| Phosphoric acid, a trace. | | |
| | 100.45 | |

The air- dried ore lost 2.2 per cent. of *moisture* when dried at 212°.

No. 73—LIMONITE. *Labeled "Black Bed, Greenup Furnace, Greenup county, Ky."*

A dull looking ore; color, reddish brown, with portions of yellowish and reddish-ochreous. The lens shows dark grains imbedded, and minute spangles of mica; adheres to the tongue. Powder of a dirty yellowish-brown color.

Composition dried at 212°—

| | | |
|---|---|---|
| Oxide of iron, - - - - | 67.50 | = 47.27 per cent of *Iron*. |
| Alumina, - - - - | 2.97 | |
| Carbonate of lime, - - - | .97 | |
| Magnesia, - - - - | 1.62 | |
| Oxide of manganese, - | 1.37 | |
| Potash, - - - - - | .38 | |
| Combined water, - - | 12.11 | |
| Silica and insoluble silicates, | 14.75 | |
| | 101.67 | |

The air-dried ore lost 1.8 per cent. of *moisture* when dried at 212° F.

No. 74—CARBONATE OF IRON. *Labeled "Limestone Ore, average quality, lies on the limestone, Greenup Furnace, Greenup county, Ky."*

Ore of a variegated appearance; some parts dark reddish-brown, others yellowish-red, others dark grey; infiltrations of calcareous spar evident. Powder of dirty yellow ochre color.

Specific gravity, - - - - - - - 3.582

Composition, dried at 212° F.—

| | | |
|---|---|---|
| Carbonate of iron, - - - | 41.98 | 43.65 per cent. of *Iron*. |
| Oxide of iron, - - - | 44.66 | |
| Carbonate of lime, - - - | 4.35 | |
| Carbonate of magnesia, - | 1.84 | |
| Carbonate of manganese, - | .86 | |
| Alumina, - - - | .55 | |
| Potash, - - - - - | .27 | |
| Soda, - - - - - - | .67 | |
| Silica and insoluble silicates, | 5.15 | |
| Phosphoric acid, a trace. | | |
| | 100.33 | |

The air-dried ore lost 0.3 per cent. of *moisture* when dried at 212° F.

No. 75—CARBONATE OF IRON. *Labeled, "Limestone Ore, best quality, resting on the limestone, Greenup Furnace, Greenup county, Ky."*

A pretty compact ore; cellular in parts; varying in color, in portions, from dark brown and dark grey, to ochreous yellow; showing fine spangles of mica under the lens. Powder of a reddish-buff, or dirty salmon color.

Specific gravity, - - - - - - - 3.445

Composition, dried at 212° F.—

| | | |
|---|---|---|
| Carbonate of iron, - - - | 70.39 | 43.20 per cent. of *Iron*. |
| Oxide of iron, - - - | 13.14 | |
| Carbonate of lime, - - - | 4.75 | |
| Carbonate of magnesia, - - | 4.68 | |
| Carbonate of manganese, - | 1.46 | |
| Alumina, - - - - - | .37 | |
| Phosphoric acid, - - - - | .18 | |
| Potash, - - - - - - | .19 | |
| Soda, - - - - - - | .05 | |
| Silica and insoluble silicates, - | 2.45 | |
| Water and loss, - - - | 2.34 | |
| | 100.00 | |

The air-dried ore lost 0.3 per cent. of *moisture*, when dried at 212° F.

No. 76.—LIMESTONE, (IMPURE.) *Labeled "Grey Limestone Ore, lies on the limestone, Greenup Furnace, Greenup county, Ky."*

External appearance like that of a dull grey granular limestone; some calcareous spar in parts; minute dark grains in a whitish cement are evident by the lens; adheres to the tongue.

Specific gravity, - - - - - - - 2.803

Composition, dried at 212° F—

| | | |
|---|---|---|
| Carbonate of lime, - - - | 71.45 | |
| Carbonate of iron, - - - | 13.19 | 7.45 per cent. of *Iron*. |
| Oxide of iron, - - - | 1.56 | |
| Carbonate of magnesia, - - | 3.73 | |
| Carbonate of manganese, - | .51 | |
| Potash, - - - - - - | .19 | |
| Soda, - - - - - - | .10 | |
| Alumina, - - - - - | .47 | |
| Silica and insoluble silicates, - | 7.33 | |
| Water and loss, - - - | 1.47 | |
| | 100.00 | |

The air-dried rock lost 0.5 per cent. of *moisture* when dried at 212° F.

No. 77—LIMESTONE. *Labeled, "Limestone used as a Flux, at Greenup Furnace, Greenup county, Ky."*

A dull looking, light grey, fine granular limestone, with organic remains, and small portions of calcareous spar.

Specific gravity, - - - - - - - 2.977

Composition, dried at 212° F.—

| | |
|---|---|
| Carbonate of lime, | 91.50 |
| Carbonate of magnesia, | 2.53 |
| Alumina, oxide of iron, &c., | 1.15 |
| Potash, | .13 |
| Soda, | .10 |
| Silica and insoluble silicates, | 3.97 |
| Loss, | .62 |
| | 100.00 |

The air-dried limestone lost 0.3 per cent. of *moisture* when dried at 212°.

### No. 78—Iron Furnace Slag. *Labeled "Cinder produced at the Greenup Furnace, Greenup county, Ky."*

A perfectly vitrified slag, of a smoky-purple color; containing very few bubbles; fusing readily before the blow-pipe into a white blebby globule.

Specific gravity, - - - - - - - 2.680

Composition, dried at 212°—

| | | | | |
|---|---|---|---|---|
| Silica, | 55.54 | Containing oxygen, | | 28.84 |
| Lime, | 19.92 | " | 5.66 | |
| Magnesia, | 2.69 | " | 1.07 | |
| Alumina, | 16.54 | " | 7.73 | |
| Protoxide of iron, | 2.10 | " | .46 | |
| Protoxide of manganese, | .69 | " | .15 | |
| Potash, | 2.30 | " | .39 | |
| Soda, | .14 | " | .092 | |
| Traces of phosphoric acid and loss, | .08 | | | |
| | 100 52 | | 15.49 : | 28.84 |
| Oxygen nearly as | | | 1. : | 1.86 |

### No. 79—Pig-iron. *Labeled "Pig-iron produced at Greenup Furnace, Greenup county, Ky."*

A dark grey iron of medium coarse texture; flattens a little under the hammer, but soon breaks to pieces; yields easily to the file.

| | | |
|---|---|---|
| Specific gravity, | | 6.877 |
| Composition— | | |
| Iron, | 91.29 | |
| Graphite, | 3.13 | = Total carbon. |
| Silicon, | 3.57 | |
| Slag, | .22 | |
| Manganese, | .48 | |
| Aluminium, | .30 | |
| Magnesium, | .18 | |
| Potassium, | .05 | |
| Phosphorus, | .67 | |
| Sulphur, | .05 | |
| Loss, | .06 | |
| | 100.00 | |

No. 80—LIMONITE. *Labeled "Soft Limestone Ore over the Ferruginous Limestone, Raccoon ore bank, Greenup county, Ky., (middle bed of ore two-thirds of way up the hill.")*

A friable, porous ore; adhering to the tongue; color from deep reddish-brown, to reddish-grey and light-grey; some portions yellowish. Powder dirty red-brown color.

| | | |
|---|---|---|
| Specific gravity, | | 3.019 |
| Composition, dried at 212° F.— | | |
| Oxide of iron, | 65.30 | = 47.82 per cent of *Iron.* |
| Alumina, | 2.65 | |
| Carbonate of lime, | .47 | |
| Magnesia, | .86 | |
| Oxide of manganese, | 1.55 | |
| Potash, | .22 | |
| Soda, | .10 | |
| Combined water, | 4.93 | |
| Silica and insoluble silicates, | 23.67 | |
| Loss, | .25 | |
| | 100.00 | |

The air-dried ore lost 2.8 per cent. of *moisture,* when dried at 212° F.

No. 81—LIMONITE. *Labeled "Block Ore, Raccoon Ore Banks, Greenup county, Ky."*

A dull looking limonite; dark brownish-red, with shades of lighter; porous; adhering to the tongue. Powder good Spanish brown color.

Specific gravity, - - - - - - - 2.766

Composition, dried at 212° F.—

| | | |
|---|---|---|
| Oxide of iron, | 76.20 | = 53.36 per cent. of *Iron*. |
| Alumina, | 2.24 | |
| Magnesia, | 1.86 | |
| Oxide of manganese, | 1.00 | |
| Potash, | .33 | |
| Soda, | .10 | |
| Combined water, | 7.60 | |
| Silica and insoluble silicates, | 11.27 | |
| | 100.60 | |

The air-dried ore lost 3.4 per cent. of *moisture*, when dried at 212° F. Besides its use as a very good iron ore, this mineral, ground to fine powder, could be employed for painting, as Spanish brown or Venetian red, according to its shade of color. These common iron pigments, not very pleasant in color, it is true, are known by experience to be amongst the best preservatives amongst the paints, for exposed wood-work. Several of the ores examined could be employed as pigments.

No. 82—LIMONITE. *Labeled "Block Ore, attached to the ferruginous limestone, under the one foot of sandstone, Raccoon Ore Banks, Greenup county, Ky."*

A dull looking dark reddish-brown ore, with some small interspersed portions of ochreous yellow; porous; adhering to the tongue, but pretty dense; contains minute spangles of mica. Powder, dull Venetian red color.

Specific gravity, - - - - - - - 3.251

Composition, dried at 212° F.—

| | | |
|---|---|---|
| Oxide of iron, | 71.90 | = 50.35 per cent. of *Iron*. |
| Alumina, | 1.67 | |
| Magnesia, | 1.13 | |
| Oxide of manganese, | 1.35 | |
| Carbonate of lime, | .27 | |
| Potash, | .24 | |
| Soda, | .06 | |
| Phosphoric acid, | .25 | |
| Combined water, | 9.22 | |
| Silica and insoluble silicates, | 14.17 | |
| | 100.26 | |

The air-dried ore lost 2.4 per cent. of *moisture*, when dried at 212° F.

No. 83—LIMONITE. *Labeled "Main Upper Kidney Ore, in the yellow shales, over the black shales, Raccoon Ore Banks, high up in the hills, Greenup county, Ky."*

In curved layers, sometimes around a nucleus; color from dark reddish-brown to reddish-ochreous-yellow; pretty dense, yet adheres slightly to the tongue. Powder of a dark reddish-brown color.

| | | |
|---|---|---|
| Specific gravity, | | 3.547 |
| Composition, dried at 212° F.— | | |
| Oxide of iron, | 80.60 | = 56.44 per cent. of *Iron*. |
| Alumina, | .87 | |
| Oxide of manganese, | .77 | |
| Magnesia, | .40 | |
| Potash, | .21 | |
| Soda, | .35 | |
| Combined water, | 9.51 | |
| Silica and insoluble silicates, | 6.97 | |
| Loss, | .37 | |
| | 100.00 | |

The air-dried ore lost 1.1 per cent. of moisture, when dried at 212° F.

No. 84—LIMESTONE. *Labeled "Limestone from Old Town creek, used as a flux, Raccoon Furnace, Greenup county, Ky."*

A dull yellowish-greenish, granular limestone; adhering slightly to the tongue. Powder of a light buff color.

| | | |
|---|---|---|
| Specific gravity, | 2.687 | |
| Composition, dried at 212° F.— | | |
| Carbonate of lime, | | 61.95 |
| Carbonate of magnesia, | | 2.35 |
| Alumina, oxide of iron, &c., | | 4.95 |
| Potash, | | .25 |
| Soda, | | .24 |
| Silica and insoluble silicates, | | 30.17 |
| Loss, | | .09 |
| | | 100.00 |

The air-dried rock lost 1. per cent. of *moisture*, when dried at 212°.

No. 85—IRON FURNACE SLAG. *Labeled "Dark Purple Slag, made at Raccoon Furnace, when producing soft grey iron, Greenup co., Ky."*

Perfectly vitrified; color, smoky purple, seen through thin fragments; free from bubbles; before blow-pipe fuses pretty easily into a white blebby globule.

Specific gravity, - - - - - - - 2.722

Composition, dried at 212° F.—

| | | | | | |
|---|---|---|---|---|---|
| Silica, - - - - - - | 56.70 | Containing oxygen, | | | 29.44 |
| Lime, - - - - - - | 24.24 | " | 6.89 | | |
| Magnesia, - - - - - | 4.41 | " | 1.76 | | |
| Alumina, - - - - - | 11.48 | " | 5.38 | | |
| Protoxide of iron, - - - | 1.02 | " | .22 | | |
| Protoxide of manganese, - - | .53 | " | .12 | | |
| Potash, - - - - - - | 1.37 | " | .23 | | |
| Soda, - - - - - - | .13 | " | .03 | | |
| Loss, - - - - - - | .12 | | | | |
| | 100.00 | | 14.63 | : | 29.44 |
| Oxygen nearly as - - - - - - - - | | | 1. | : | 2.01 |

A very good slag.

No. 86—IRON FURNACE SLAG. *Labeled "Green and Purple Porous Light Cinder, produced at Raccoon Furnace when working best, Greenup county, Ky."*

Opaque, and spongy from the presence of myriads of minute air bubbles; general color greenish-grey, some portions purplish; containing some small particles of reduced iron; in some spots it is brownish, from the presence of peroxide of iron; before the blow-pipe it appears not quite as fusible as the preceding, melting into a clear glass.

Composition—

| | | | | | |
|---|---|---|---|---|---|
| Silica, - - - - - - | 61.84 | Containing oxygen, | | | 32.11 |
| Lime, - - - - - - | 18.34 | " | 5.21 | | |
| Magnesia, - - - - - | 2.40 | " | 0.96 | | |
| Alumina, - - - - - | 13.00 | " | 6.07 | | |
| Protoxide of iron, - - - | 2.97 | " | .66 | | |
| Protoxide of manganese, - - | .31 | " | .07 | | |
| Potash, - - - - - - | 1.08 | " | .18 | | |
| Soda, - - - - - - | .15 | " | .04 | | |
| Trace of phosphoric acid. | | | | | |
| | 100.09 | | 13.19 | : | 32.11 |
| Oxygen in the proportion of - - - - - - | | | 1. | : | 2.43 |

A slag of more difficult fusion than any of the preceding.

No. 87—PIG-IRON. *Labeled "Soft Grey Iron, produced at Raccoon Furnace, when making dark purple cinder, Greenup county, Ky."*

A brilliant specimen; of medium fine texture; of a grey color; yields easily to the file, but scarcely flattens under the hammer before it breaks to pieces; more easily powdered than any of the preceding specimens; dissolves sluggishly in diluted hydrochloric acid.

Specific gravity, - - - - - - - 6.898

Composition—

| | | | |
|---|---|---|---|
| Iron, | 90.18 | | |
| Graphite, | 2.80 | Total carbon, | 3.80 |
| Combined carbon, | 1.00 | | |
| Silicon, | 5.13 | | |
| Slag, | .93 | | |
| Manganese, | .59 | | |
| Aluminium, | .08 | | |
| Potassium, | .05 | | |
| Magnesium, | .07 | | |
| Phosphorus, | .37 | | |
| Sulphur, | .01 | | |
| | 101.21 | | |

Contains quite a large proportion of silicon and slag.

No. 88—PIG-IRON. *Labeled "Pig-iron of medium texture, produced when pea-green cinder is formed, Raccoon Furnace, Greenup co., Ky."*

Rather coarser grained, and darker colored, and less brilliant than the preceding; yields easily to the file; flattens a little more under the hammer than 86; is somewhat tougher, yet easily hammered to powder.

Specific gravity, - - - - - - - - 6.798

Composition—

| | | | |
|---|---|---|---|
| Iron, | 91.85 | | |
| Graphite, | 2.40 | Total carbon, | 3.13 |
| Combined carbon, | .73 | | |
| Silicon, | 3.55 | | |
| Slag, | .51 | | |
| Manganese, | .18 | | |
| Aluminium, | .09 | | |
| Potassium, | .06 | | |
| Magnesium, | .08 | | |
| Phosphorus, | .34 | | |
| Sulphur, | .04 | | |
| Loss, | .17 | | |
| | 100.00 | | |

No. 89—PIG-IRON. *Labeled "High Iron, produced when furnace is working stiff, especially with grey block ore, Raccoon Furnace, Greenup county, Ky."*

Lighter colored, finer grained, and more compact than the two preceding specimens; yields with difficulty to the file; not sensibly flattened under the hammer, but very easily crushed to powder.

Specific gravity, - - - - - - - 6.867

Composition—

| | | | |
|---|---|---|---|
| Iron, | 88.57 | | |
| Graphite, | 2.25 | Total carbon, | 4.25 |
| Combined carbon, | 2.00 | | |
| Silicon, | 6.88 | | |
| Slag, | .47 | | |
| Manganese, | .63 | | |
| Aluminium, | .15 | | |
| Potassium, | .03 | | |
| Magnesium, | .15 | | |
| Phosphorus, | .44 | | |
| Sulphur, (not estimated.) | | | |
| | 101.57 | | |

Contains an unusually large proportion of silicon. Is probably produced when the cinder has not the right composition to give it a proper degree of fusibility, and when the furnace has been urged to its greatest heat.

No. 90—COAL. *Labeled "Thirty-Inch Coal, three hundred feet above Raccoon creek, one mile north-east of Raccoon Furnace, Greenup county, Ky.*

A slaty coal; rather tough; of a dull black appearance, except on the cross fracture of the thin layers; these are coated with fibrous coal, which shows vegetable impressions, and is infiltrated with pyrites. Heated over the spirit-lamp it decrepitated strongly; swelled up somewhat, but not sufficient to show that it is a coking coal. It is a splint coal.

Specific gravity, - - - - - - - 1.320

Composition, dried at the ordinary temperature—

| | | | |
|---|---|---|---|
| Moisture, | 3.90 | Total volatile matters, | 41.20 |
| Volatile combustible matters, | 37.30 | | |
| Carbon in the coke, | 50.20 | Moderately dense coke, | 58.80 |
| Ashes, (purplish-grey,) | 8.60 | | |
| | 100.00 | | 100.00 |

Composition, dried at 212°—

| | |
|---|---|
| Volatile combustible matters, | 38.814 |
| Carbon in the coke, | 52.237 |
| Ashes, | 8.949 |
| | 100.000 |

The per centage of *sulphur* was found to be 1.448. The ashes contained *scarcely* a trace of sulphate of lime.

No. 91—Coal. *Labeled "Under part of eight to ten-inch coal in the bed of Raccoon creek, three hundred and thirty feet under main ore bank of Raccoon Furnace, Greenup county, Ky."*

A dull looking coal of a slaty structure; fibrous coal with vegetable impressions on the layers; cross fracture deep black color, and moderate pitch-like lustre; no appearance of pyrites or other impurities; outside part with an earthy or ochreous incrustation. Over the spirit-lamp, decrepitated slightly; swelled up somewhat, but did not soften much nor agglutinate. A splint coal.

Specific gravity, 1.393

Composition, dried at the ordinary temperature—

| | | | |
|---|---|---|---|
| Moisture, | 5.20 | Total volatile matters, | 35.50 |
| Volatile combustible matters, | 30.30 | | |
| Carbon in the coke, | 55.30 | Carbonaceous residue, | 64.50 |
| Ashes, (nearly white,) | 9.20 | | |
| | 100.00 | | 100.00 |

Composition, dried at 212°—

| | |
|---|---|
| Volatile combustible matters, | 31.962 |
| Carbon in the fixed residue, | 58.333 |
| Ashes, | 9.705 |
| | 100.000 |

The proportion of *sulphur* is only 0.453. The ashes contained merely a trace of sulphate of lime. This is quite a dry splint coal, which scarcely swells or agglutinates when exposed to heat; hence it would answer for the smelting of iron without previous coking. With such a coal as this, and the hot blast, the cheaper kinds of iron for common purposes, such as railroad iron, can be most economically made.

No. 92—**SANDSTONE.** *Labeled "Sandstone under Main Coal, at Raccoon Furnace, used for hearth stones, Greenup county, Ky."*

A fine grained friable sandstone of a light buff color; composed of rounded grains of sand, with a few minute scales of mica; a little oxide of iron, and little or no cementing material.

Specific gravity, - - - - - - - - - 2.151

Composition, dried at 212° F.—

| | |
|---|---|
| Sand, | 97.80 |
| Alumina, oxide of iron, &c., | .53 |
| Carbonate of lime, | .07 |
| Carbonate of magnesia, | .25 |
| Potash, a trace. | |
| Moisture and loss, | 1.55 |
| | 100.00 |

As it is nearly pure silex, it is well adapted to withstand a high temperature without melting. Pure silex can be fused only by such a very high temperature as is produced by the oxy-hydrogen blow-pipe. The mixture with it of lime, magnesia, potash, oxide of iron, alumina and other bases, as is well known, causes it to melt at a much lower temperature to produce glass, enamel, slag, &c.

No. 93—**LIMONITE.** *Labeled "Yellow Kidney Ore, Amanda Furnace, above the Main Coal, Greenup county, Ky."*

A pretty dense, dull looking ore; adheres somewhat to the tongue; color from dark reddish-brown to dirty ochre, in concentric veins, and stripes like the colors in some kinds of jasper. Powder of a dark buff, or dark, dirty, salmon color.

Specific gravity, - - - - - - - - - 3.011

Composition, dried at 212° F.—

| | | |
|---|---|---|
| Oxide of iron, | 56.50 | = 39.56 per cent. of *Iron.* |
| Carbonate of lime, | 7.27 | |
| Alumina, | 2.95 | |
| Oxide of manganese, | 1.00 | |
| Magnesia, | 2.30 | |
| Potash, | .26 | |
| Soda, | .11 | |
| Combined water, | 11.34 | |
| Silica and insoluble silicates, and trace of phosphoric acid, | 18.27 | |
| | 100.00 | |

The air-dried ore lost 1.3 per cent. of *moisture*, when dried at 212°.

No. 94—Limonite. *Labeled "Red and Blue mixed Block Ore, Amanda Furnace, Greenup county, Ky."*

A dark, reddish-brown, limonite; dull; porous; adhering to the tongue; some portions almost black, others lighter colored; contains a few specks of calcareous spar, and minute scales of mica. Powder, Spanish-brown color.

| | | |
|---|---|---|
| Specific gravity, | | 2.835 |
| Composition, dried at 212° F.— | | |
| Oxide of iron, | 62.90 | = 44.04 per cent. of *Iron*. |
| Alumina, | 3.15 | |
| Carbonate of lime, | .57 | |
| Magnesia, | .68 | |
| Potash, | .32 | |
| Soda, | .04 | |
| Sulphur, | .15 | |
| Manganese, a trace. | | |
| Phosphoric acid, a trace. | | |
| Combined water, | 8.41 | |
| Silica and insoluble silicates, | 24.97 | |
| | 101.19 | |

The air-dried ore lost 2.6 per cent. of *moisture*, when dried at 212° F.

No. 95—Limonite. *Labeled "Honey-comb Ore, over the limestone, with limestone ore, Amanda Furnace, Greenup county, Ky."*

Irregular in form, containing cavities; interior, pretty hard, of a dark rust-brown color; exterior, ochreous. Powder, brownish-buff color.

| | | |
|---|---|---|
| Specific gravity, | | 2.914 |
| Composition, dried at 212° F.— | | |
| Oxide of iron, | 81.87 | = 57.33 per cent. of *Iron*. |
| Phosphate of alumina, | .97 | |
| Phosphoric acid, | .23 | |
| Oxide of manganese, | .55 | |
| Magnesia, | .33 | |
| Potash, | .07 | |
| Soda, | .14 | |
| Combined water, | 12.39 | |
| Silica and insoluble silicates, | 3.67 | |
| | 100.22 | |

The air-dried ore lost 1.6 per cent. of *moisture*, when dried at 212° F.

No. 96—LIMONITE. *Labeled "Best Limestone Ore, below Main Coal, Amanda Furnace, Greenup county, Ky."*

A dull looking ore, of a dark reddish-brown color; exterior layers, dull ochreous; structure irregularly laminated; the lens shows minute dark granules, imbedded in a lighter colored substance, and some infiltrations of spar. Powder, rich brownish-yellow ochre color.

| | | |
|---|---|---|
| Specific gravity, | | 3.072 |
| Composition, dried at 212° F.— | | |
| Oxide of iron, | 57.10 | = 40.03 per cent. of *Iron*. |
| Carbonate of lime, | 9.35 | |
| Magnesia, | 1.49 | |
| Alumina, | 1.65 | |
| Oxide of manganese, | .37 | |
| Potash, | .08 | |
| Soda, | .09 | |
| Combined water, | 9.80 | |
| Silica and insoluble silicates, | 20.07 | |
| | 100.00 | |

The air-dried ore lost 1. per cent. of *moisture*, when dried at 212° F.

No. 97—CARBONATE OF IRON. *Labeled "Blue Block Ore, with black shale immediately under it; impracticable by itself; lowest bed worked at Amanda Furnace, Greenup county, Ky."*

A dull looking ore, of a dark greenish-grey color mixed with reddish; surfaces of fissures reddish where it has been exposed to the air; adhering to the tongue. Powder, greyish-buff color.

| | | |
|---|---|---|
| Specific gravity, | | 3.391 |
| Composition, dried at 212°— | | |
| Carbonate of iron, | 79.72 | 41.26 per cent of *Iron*. |
| Oxide of iron, | 4.52 | |
| *Alumina and phosphoric acid, | .42 | |
| Carbonate of lime, | .97 | |
| Carbonate of magnesia, | 3.08 | |
| Carbonate of manganese, | 1.23 | |
| Potash, | .24 | |
| Soda, | .18 | |
| Silica and insoluble silicates, | 9.64 | |
| | 100.00 | |

*Phosphoric acid 0.34 per cent.

The air-dried ore lost 0.7 per cent. of *moisture*, when dried at 212° F. "Impracticable by itself," probably because it is a carbonate, which would readily melt on the sudden application of a great heat, and, particularly, because it contains but a small proportion of the materials for the formation of cinder.

No. 98—IRON FURNACE SLAG. *Labeled "Pea-green Cinder, usually produced when working the blue limestone ore and block ore, at Amanda Furnace, Greenup county, Ky."*

Color, rather olive-green than pea-green; well vitrified, but nearly opaque, from the presence in it of minute air bubbles; translucent on the edges; before the blow-pipe, quite fusible, melting into a blebby globule.

| | | | | | |
|---|---|---|---|---|---|
| Composition, dried at 212° F.— | | | | | |
| Silica, | 50.94 | Containing oxygen, | | | 26.45 |
| Lime, | 23.77 | " | 5.76 | | |
| Magnesia, | 3.19 | " | 1.27 | | |
| Alumina, | 15.50 | " | 7.24 | | |
| Protoxide of iron, | 2.61 | " | .60 | | |
| Protoxide of manganese, | 1.58 | " | .35 | | |
| Potash, | 2.24 | " | .38 | | |
| Soda, | .77 | " | .20 | | |
| Phosphoric acid, a trace. | | | | | |
| | 100.00 | | 15.80 | : | 26.45 |
| Oxygen nearly as | | | 1. | : | 1.67 |

The proportion of lime, &c., to the silica, is rather larger than is absolutely necessary to its proper fusibility; but this excess favors, to some extent, the separation of phosphorus and sulphur from the iron—injurious ingredients, which cause the formation of *white* iron; the former, phosphorus, in too large proportion, makes it brittle in the cold or "*cold short*," and the latter makes it "*hot short*."

No. 99—PIG-IRON. *Labeled "Pig-iron produced from the red and blue block ore, lowest bed, Amanda Furnace, Greenup county, Ky."*

A silver-white iron, very fine-grained, and compact; broken under the hammer and reduced to powder with the greatest difficulty; so very hard as to indent the faces of hammer and anvil; resisting the file like the hardest steel.

Specific gravity, - - - - - - - 7.433

Composition—

| | | |
|---|---|---|
| Iron, | 94.89 | |
| Combined carbon, | 3.00 | (No graphite.) |
| Silicon, | 1.55 | |
| Slag, | .11 | |
| Aluminium, a trace. | | |
| Manganese, | .21 | |
| Potassium, | .05 | |
| Magnesium, | .09 | |
| Phosphorus, | .79 | |
| Sulphur, | .20 | |
| | 100.89 | |

This is decidedly the hardest *white* iron of all the specimens examined. We attribute its *high white* condition partly to the phosphorus and sulphur which it contains—more especially to the sulphur—which by favoring the actual *combination* of the carbon with the iron—instead of its separation, as graphite, in the act of cooling, which characterizes soft grey iron—gives it the properties of hardened steel. Its considerable proportion of manganese also aids in producing this condition of things.

The only method for diminishing these injurious ingredients, and producing a grey soft iron, is to increase the proportion of limestone used as a flux, to the greatest extent compatible with the proper fusibility of the cinder.

With good management in the furnace it is probable that a metal might be obtained from these ores which would be admirably adapted to the formation of steel, provided a too great proportion of phosphorus does not remain to injure the tenacity of the iron.

### No. 100—CARBONATE OF IRON. *Labeled "Shot Iron Ore, below Main coal, Ashland, Greenup county, Ky."*

A friable mass, composed of dark brown granules about the size of black mustard seed, united by a soft white cement. Powder, light yellowish-grey color.

Composition, dried at 212° F.—

| | | |
|---|---|---|
| Carbonate of iron, | 60.36 | = 30.46 per cent. of *Iron*. |
| Oxide of iron, | 2.33 | |
| Alumina, | 2.65 | |
| Carbonate of lime, | 3.35 | |
| Carbonate of magnesia, | 3.58 | |
| Carbonate of manganese, | 1.43 | |
| Potash, | .49 | |
| Soda, | .05 | |
| Silica and insoluble silicates, | 24.67 | |
| Water and loss, | 1.09 | |
| Phosphoric acid, a trace. | | |
| | 100.00 | |

The air-dried ore lost 0.7 per cent. of *moisture*, when dried at 212° F. A very good iron ore.

No. 101—COAL. *Labeled "Main Ashland Coal, above clay parting, best for coking? Greenup county, Ky."*

A very pure looking soft bituminous coal, of a deep pitch-black color, and strong lustre; easily broken. Heated over the spirit-lamp it softened and swelled a great deal, and left a bulky coke. It seems to be a "fat" bituminous coal, well adapted to coking.

Specific gravity, - - - - - - - - - 1.288

Composition, dried at the ordinary temperature—

| | | | |
|---|---|---|---|
| Moisture, | 3.40 | Total volatile matters, | 38.30 |
| Volatile combustible matters, | 34.90 | | |
| Carbon in the coke, | 57.90 | Spongy coke, | 61.70 |
| Ashes, (purplish-grey,) | 3.80 | | |
| | 100.00 | | 100.00 |

Composition, dried at 212° F.—

| | |
|---|---|
| Volatile combustible matters, | 36.13 |
| Carbon in the coke, | 59.94 |
| Ashes, | 3.93 |
| | 100.00 |
| The per centage of *sulphur* is, | 0.734 |

The ashes contain 0.093 per cent. of sulphate of lime.

This is not *quite* so soft and *bituminous* as the best Pittsburg coal, but it is sufficiently so, doubtless, to answer all the purposes of the blacksmith and the founder. It is also well suited to production of *gas*, of which it will probably yield a larger proportion than the Pittsburg or Youghioghany coal.

It is to be remarked, however, that the relative proportion of the *volatile matters* of a coal will not give correct indications of the quantity of good illuminating gas which it will yield; for the reason that this *volatile matter* may consist of larger or smaller proportions of sulphur, nitrogen, and oxygen, as well as of carburets of hydrogen of various composition. *Ultimate* chemical analyses of the coals, (i. e. ascertaining the true proportions of their elementary constituents, the carbon, hydrogen, oxygen, nitrogen, sulphur, and earthy matter,) would give correct data in this relation.

The soft, light, bituminous coals are preferred by the manufacturers of coal gas, in this country, to the hard and dense splint and cannel coals, which really contain a larger proportion of *volatile matters*, not only because the residuary coke has a greater commercial value, but because the relative amount of good gas obtained is greater, in proportion to the cost of production. The true explanation of which fact is, that the *dry* coals, so called, the splint and cannel coals, contain usually a much larger proportion of *oxygen* than the soft, fat, bituminous, and coking coals. This oxygen combines with some of the hydrogen and carbon of the coal during its destructive distillation, in the manufacture of gas, to produce vapor of water and carbonic oxide gas, and thus diminishes the value of the product.

During the burning of these varieties of coal, a marked difference in phenomena results from the relative difference in the proportion of the oxygen which enters into their composition.

The fat, bituminous coal, which contains but little oxygen, softens much, and burns with a very smoky flame—giving off much soot or unburned carbon—like the pure hydrocarbons, oil of turpentine, mineral naphtha, &c., or the bituminous substances, petroleum, asphaltum, &c.; while the *dry* coals, called splint, cherry, and cannel coals, do not soften much, or at all, burn with a clearer flame, and deposit relatively little soot; burning somewhat in the manner of alcohol, ether, and the other combustibles which contain a considerable proportion of oxygen in their elementary composition.

It is obvious, from these facts, that it would have greatly facilitated the knowledge of the relative value of our Kentucky coals, could they have been submitted to *elementary* analyses; but the limited time allotted the chemical investigation, during the past seasons, absolutely precluded attention to this important examination. Should the survey be continued, it is hoped that this field may be fully explored.

No. 102—COAL. *Labeled "Coal with slate roof, first bed above Ashland Main Coal, Greenup county, Ky."*

A pure looking, intensely black coal, with a high lustre, scarcely soiling the fingers; coated on the outside with ochreous oxide of iron; some fibrous coal between the layers; showing vegetable impressions, and somewhat infiltrated with pyrites; heated over the spirit-lamp, it swelled up and softened considerably; probably a coking coal, but not quite so good for this purpose as the preceding.

Specific gravity, - - - - - - - - - 1.301

Composition, dried at the ordinary temperature—

| | | | |
|---|---|---|---|
| Moisture, - - - - | 5.00 | Total volatile matters, | 40.70 |
| Volatile combustible matters, | 35.70 | | |
| Carbon in the coke, - - | 51.00 | Moderately dense coke, | 59.30 |
| Ashes, (lilac colored,) - | 8.30 | | |
| | 100.00 | | 100.00 |

Composition, dried at 212° F.—

| | |
|---|---|
| Volatile combustible matters, - - - - - | 37.579 |
| Carbon in the coke, - - - - - - - | 53.685 |
| Ashes, - - - - - - - - - - | 8.736 |
| | 100.000 |
| The per cent. of *sulphur* is, - - - - - | 1.818 |

The ashes contained about 0.09 per cent. of sulphate of lime. A very good bituminous coal, not quite as pure as the preceding, No. 100. (See Nos. 123 and 124 for other Ashland specimens.)

No. 103—LIMONITE. *Labeled "Block Ore, principally used at the New Hampshire Furnace, Greenup county, Ky."*

A dull looking limonite, in irregular masses, partly in curved layers; color from dull reddish-brown to dull ochreous; adhering slightly to the tongue; containing minute scales of mica. Powder of brownish-yellow ochre color.

Specific gravity, - - - - - - - - - 3.111

Composition, dried at 212° F.—

| | | |
|---|---|---|
| Oxide of iron, - - - | 57.90 | = 40.53 per cent. of *Iron*. |
| Alumina, - - - - - | 2.77 | |
| Magnesia, - - - - - | .72 | |
| Oxide of manganese, - - | .25 | |
| Potash, - - - - - - | .32 | |
| Soda, - - - - - - | .10 | |
| Combined water, - - - | 10.03 | |
| Silica and insoluble silicates, - | 27.67 | |
| Phosphoric acid, a trace. | | |
| Loss, - - - - - - | .24 | |
| | 100.00 | |

The air-dried ore lost 1.3 per cent. of *moisture*, when dried at 212° F.

No. 104—LIMONITE. *Labeled "Variety of Block Ore, New Hampshire Furnace, Greenup county, Ky."*

Resembles the last, but is not in layers; adheres more to the tongue; is more porous, appears rather more granular under the lens, and shows more glimmering specks of mica. Powder, dirty-yellow ochre color.

Specific gravity, - - - - - - - 2.708

Composition, dried at 212° F.—

| | | |
|---|---|---|
| Oxide of iron, - - - - | 13.25 | = 9.27 per cent. of *Iron*. |
| Alumina, - - - - - | 4.95 | |
| Carbonate of lime, - - - | 1.67 | |
| Phosphate of lime, - - - | .90 | = Containing 0.5 of phos. acid. |
| Magnesia, - - - - - | .61 | |
| Combined water, - - - | 4.37 | |
| Silica and insoluble silicates, - | 74.36 | |
| | 100.11 | |

This can hardly be called an iron ore; and its considerable proportion of phosphate of lime makes it less valuable for the purpose of fluxing.

No. 105—LIMONITE. *Labeled "Kidney Ore, used occasionally at New Hampshire Furnace, Greenup county, Ky."*

In thin curved layers, the exterior of which is brownish-yellow ochreous; interior, dark reddish-brown. Powder, between umber and yellow ochre color.

Composition, dried at 212° F.—

| | | |
|---|---|---|
| Oxide of iron, | 56.70 | = 39.70 per cent. of *Iron*. |
| Alumina, | 3.75 | |
| Magnesia, | .63 | |
| Oxide of manganese, | .42 | |
| Potash, | .32 | |
| Soda, | .17 | |
| Combined water, | 12.04 | |
| Silica and insoluble silicates, | 25.97 | |
| | 100.00 | |

The air-dried ore lost 2. per cent. of *moisture*, when dried at 212° F.

### No. 106—LIMONITE. *Labeled "Dark Red Limestone Ore, New Hampshire Furnace, Greenup county, Ky."*

A very dark, reddish-brown, almost black ore, mottle with dark red; dull; porous; adhering slightly to the tongue; some minute infiltrations of white spar. Powder, dark reddish-brown color.

Specific gravity, - - - - - - 2.363

Composition dried at 212°—

| | | |
|---|---|---|
| Oxide of iron, | 64.70 | = 45.31 per cent of *Iron*. |
| Carbonate of lime, | 16.50 | |
| Oxide of manganese, | 2.15 | |
| Magnesia, | 1.84 | |
| Alumina, | .27 | |
| Potash, | .23 | |
| Soda, | .05 | |
| Combined water, | 7.12 | |
| Silica and insoluble silicates, | 6.47 | |
| Loss, | .67 | |
| | 100.00 | |

The air-dried ore lost 1.7 per cent. of *moisture*, when dried at 212° F.

### No. 107—LIMONITE. *Labeled "Poor Sandy Ore, not much used, at New Hampshire Furnace, Greenup county, Ky."*

A dull looking, granular ore, containing a considerable proportion of clear, rounded grains of sand, cemented and mixed with brown oxide of iron, in some places with a pink and yellowish-white cementing material. Powder, brick-red color.

| | | |
|---|---|---|
| Specific gravity, | | ? |
| Composition, dried at 212°— | | |
| Oxide of iron, | 32.10 | = 22.48 per cent. of *Iron*. |
| Alumina, | 1.47 | |
| Magnesia, | .33 | |
| Potash, | .12 | |
| Combined water, | 4.61 | |
| Silica and insoluble silicates, | 61.37 | |
| | 100.00 | |

This might be advantageously used at the New Hampshire Furnace to mix, in proper proportion, with the next preceding ore, No. 105, which is deficient in silicious ingredients. The block ore, principally used there, needs no other addition than limestone.

No. 108—FERRUGINOUS LIMESTONE. *Labeled "Ferruginous Limestone, passing into limestone ore, New Hampshire Furnace, Greenup county, Ky."*

Color, passing from fawn color to dirty ochreous; with some mottlings; dull; scarcely adhering to the tongue. Powder, dirty buff color.

| | | |
|---|---|---|
| Specific gravity, | 2.680 | |
| Composition, dried at 212° F.— | | |
| Carbonate of lime, | | 53.85 |
| Carbonate of magnesia, | | 22.10 |
| Carbonate of iron, | | 7.41 |
| Oxide of iron, | | 4.41 |
| Carbonate of manganese, | | .86 |
| Alumina, | | .37 |
| Potash, | | .21 |
| Soda, | | .19 |
| Phosphoric acid, a trace. | | |
| Silica and insoluble silicates, | | 7.97 |
| Water and loss, | | 2.63 |
| | | 100.00 |

The air-dried limestone lost 0.6 per cent. of *moisture*, when dried at 212° F.

No. 109—LIMESTONE. *Labeled "Limestone used as a flux, from the Brushey fork of Tygert's creek, under the limestone ore, New Hampshire Furnace, Greenup county, Ky."*

A light drab-grey, compact limestone; sparkling with very small portions of imbedded calcareous spar.

Specific gravity, - - - - - - - 2.700

Composition, dried at 212°F.—

| | |
|---|---|
| Carbonate of lime, | 97.85 |
| Magnesia, | 1.30 |
| Alumina, oxide of iron, &c., | .55 |
| Potash, | .15 |
| Soda, | .50 |
| Silicious residue, | 1.27 |
| | 101.62 |

A pretty pure limestone. Dried at 212°, the air-dried limestone lost 0.3 per cent. of *moisture.*

No. 110—Iron Furnace Slag. *Labeled "Dark Purple Glassy Cinder, produced when making soft grey iron, New Hampshire Furnace, Greenup county, Ky."*

Perfectly vitrified; of a more smoky tinge than any of the preceding, with a slight tint of purple or violet; rather clearer, in thin pieces, than those previously examined; rather difficult of fusion; melting, before the blow-pipe, into a white blebby globule.

Specific gravity, - - - - - - - 2.719

Composition, dried at 212° F.—

| | | | | |
|---|---|---|---|---|
| Silica, | 56.28 | Containing oxygen, | | 29.22 |
| Lime, | 19.70 | " | 5.57 | |
| Magnesia, | 6.13 | " | 2.45 | |
| Alumina, | 13.90 | " | 6.49 | |
| Protoxide of iron, | 1.56 | " | .35 | |
| Protoxide of manganese, | 1.02 | " | .23 | |
| Potash, | 1.26 | " | .21 | |
| Loss, | .15 | | | |
| | 100.00 | | 15.30 : | 29.22 |
| Oxygen nearly as, | | | 1. : | 1.91 |

No. 111—Iron Furnace Slag. *Labeled, "White Heavy Cinder, produced at New Hampshire Furnace, Greenup county, Ky."*

A compact, greyish-white slag, of considerable density; nearly opaque, looking like some kinds of hornstone; containing a few small air bubbles, and some small pieces of reduced iron; before the blowpipe it phosphoresced somewhat like lime or magnesia; proved quite fusible; intermesced greatly, and settled down into a white blebby globule.

Specific gravity, - - - - - - - - 2.787

Composition, dried at 212°—

| | | | | | |
|---|---|---|---|---|---|
| Silica, | 56.34 | Containing oxygen, | | | 29.25 |
| Lime, | 19.56 | " | 5.57 | | |
| Magnesia, | 6.59 | " | 2.63 | | |
| Alumina, | 14.30 | " | 6.68 | | |
| Protoxide of iron, | 1.36 | " | .30 | | |
| Protoxide of manganese, | .87 | " | .20 | | |
| Potash, | 1.00 | " | .17 | | |
| Soda, | .22 | " | .06 | | |
| | 100.00 | | 15.61 | : | 29.25 |
| Oxygen nearly as | | | 1. | : | 1.87 |

No. 112—IRON FURNACE SLAG. *Labeled "Pea-green Cinder, produced when making a good run, but iron somewhat close-grained. New Hampshire Furnace, Greenup county, Ky."*

Composition, dried at 212°—

| | | | | | |
|---|---|---|---|---|---|
| Silica, | 56.74 | Containing oxygen, | | | 29.46 |
| Lime, | 16.66 | " | 4.74 | | |
| Magnesia, | 5.20 | " | 2.08 | | |
| Alumina, | 15.10 | " | 7.06 | | |
| Protoxide of iron, | 2.17 | " | .48 | | |
| Protoxide of manganese, | 2.92 | " | .65 | | |
| Potash, | 1.66 | " | .28 | | |
| Soda, | .36 | " | .09 | | |
| | 100.81 | | 15.38 | : | 29.46 |
| Oxygen nearly as, | | | 1. | : | 1.91 |

The first two slags, (110 and 111,) do not differ much in composition—the former is probably formed when there is an accidental excess of carbonaceous matter present; the latter when the oxygen of the blast somewhat prevails. In this last, the smaller proportion of *lime* present throws some light on the simultaneous production of fine-grained iron. The addition of more limestone would probably correct this.

113—PIG-IRON. *Labeled "Grey Pig-iron, New Hampshire Furnace, Greenup county, Ky."*

A coarse grained, dark colored iron; flattens somewhat under the hammer, but soon breaks to pieces, and easily pounds to powder; yields easily to the file.

| | | |
|---|---|---|
| Specific gravity, | | 6.843 |
| Iron, | 93.12 | |
| Graphite, | 2.83 | |
| Silicon, | 1.23 | |
| Slag, | .13 | |
| Manganese, | .34 | |
| Aluminium, | .52 | |
| Potassium, | .33 | |
| Sodium, | .21 | |
| Phosphorus, | 1.30 | |
| Magnesium, | .06 | |
| | 100.00 | |

No. 114—PIG-IRON. *Labeled "Close textured Pig-iron, New Hampshire Furnace, Greenup county, Ky."*

A very fine grained light-grey iron; flattens considerably under the hammer, but is readily pounded to powder; yields easily to the file; is a soft iron notwithstanding its light color.

| | | |
|---|---|---|
| Specific gravity, | | 7.241 |
| Composition— | | |
| Iron, | 93.19 | |
| Graphite, | 3.13 | |
| Silicon, | 1.28 | |
| Slag, | .18 | |
| Manganese, | .20 | |
| Aluminium, | .44 | |
| Potassium, | .19 | |
| Sodium, | .09 | |
| Magnesium, | .06 | |
| Phosphorus, | 1.40 | |
| Sulphur, a trace. | | |
| | 100.16 | |

These two specimens of pig-iron are remarkable for their large relative proportion of phosphorus and of aluminium. The former most probably gives to them *cold-short* properties, as they are very easily pounded to powder on the anvil; the presence of the aluminium, with the absence of a notable quantity of sulphur, may be the cause why this iron, although quite light colored, is yet soft; yielding easily to the file.

According to the well known experiments of Faraday and Stodart in England, the celebrated India Steel—the *Wootz*—of which are fabricated the Damascus blades, owes its peculiar excellence to the presence of aluminium, which they found in it in proportions varying from 1.3 to 0.024 per cent. The usually correct Karsten is, however, disposed to doubt their conclusions in this respect, although they are corroborated by the experiments of Mushet. It is probable, from the account which Karsten gives of his mode of investigation, (Band 1, section 484, of his *Handbuch der Eisenhuttenkunde,*) that the aluminium which might have been present in the steel which he submitted to analyses escaped his observation.

The recent interesting experiments of Deville and others, in France, in the production of aluminium in quantity, at a low price, prove that it can easily be alloyed with iron, as well as with many other metals. Its alloy with copper is light, hard and white. From its low specific gravity, only 2.56, it doubtless also reduces the relative weight of iron with which it is combined. Aluminium, the metallic basis of the earth of clay, (alumina,) has been recently introduced into the arts, in France, at a cost of about one-fifth of that of silver. It is a light, malleable metal, nearly as white as silver, of great sonorousness, which may be heated and melted without any loss by oxidation; it does not rust in the moist air.

No. 115—SANDSTONE. *Labeled "Hearth Sandstone, New Hampshire Furnace, Greenup county, Ky."*

A yellowish-grey fine-grained friable sandstone, containing small scales of mica; the grains of sand are rounded, and are cemented by a small amount of ferruginous material; structure somewhat lamellar.

| | | |
|---|---|---|
| Specific gravity, | 2.458 | |
| Composition, dried at 212° F.— | | |
| Sand, | | 94.855 |
| Oxide of iron, alumina, &c., | | 2.775 |
| Carbonate of lime, | | .197 |
| Carbonate of magnesia, | | .837 |
| Potash, | | .164 |
| Soda, | | .047 |
| Loss, | | 1.125 |
| | | 100.000 |

No. 116—SANDSTONE. *Labeled "Hearth-stone after two months exposure in New Hampshire Furnace, Greenup county, Ky."*

Much harder, (less friable,) and more compact than the preceding;

scarcely adhering to the tongue; color, bluish-grey with darker thin lines of stratification; no scales of mica visible.

Specific gravity, - - - - - - - 2.407

Composition, dried at 212° F.—

| | |
|---|---|
| Sand, &c., | 98.835 |
| Oxide of iron, alumina, &c., | .325 |
| Carbonate of lime, | .055 |
| Magnesia, | .249 |
| Potash, | .154 |
| Soda, | .029 |
| Loss, | .353 |
| | 100.000 |

If these sandstones were of similar composition at first, the intense heat to which the last specimen was exposed, seems to have removed some of the substances with which the sand composing it was mixed. How this occurred is not easily explained, unless we suppose it took place by sublimation.

No. 117—LIMONITE. *Labeled "Mount Savage Main Ore, Greenup county, Ky."*

A dark, reddish-brown limonite; pretty dense; irregularly cellular; powder, dark Spanish-brown color.

Specific gravity, - - - - - - - 3.062

Composition, dried at 212° F.—

| | | |
|---|---|---|
| Oxide of iron, | 85.16 | = 59.63 per cent. of *Iron*. |
| Alumina, | .84 | |
| Oxide of manganese, | .95 | |
| Magnesia, | .59 | |
| Potash, | .25 | |
| Silica and insoluble silicates, | 4.57 | |
| Combined water, | 7.30 | |
| Loss, | .34 | |
| | 100.00 | |

The air-dried ore lost 1.4 per cent. of *moisture*, when dried at 212° F.

No. 118—CARBONATE OF IRON. *Labeled "Mount Savage Iron Ore, under Main Ashland Coal, Greenup county, Ky."*

A dark, umber-grey, fine granular mineral, having the appearance of a dull earthy variety of limestone. Specimen contains a concretionary cast, as of a portion of a branching coral stem, which is of a light lead color. Powder, light umber color.

| | | |
|---|---|---|
| Specific gravity, | | 3.468 |
| Composition, dried at 212° F— | | |
| Carbonate of iron, | 70.60 | 37.53 per cent. of *Iron*. |
| Oxide of iron, | 5.42 | |
| Carbonate of lime, | 2.15 | |
| Carbonate of magnesia, | 4.91 | |
| Carbonate of manganese, | 1.25 | |
| Alumina, | 1.55 | |
| Potash, | .25 | |
| Soda, | .09 | |
| Silica and insoluble silicates, | 13.37 | |
| Loss, | .41 | |
| | 100.00 | |

The air-dried ore lost 1.4 per cent. of *moisture*, when dried at 212° F.

Both of these are very good iron ores. The first, No. 117, may require the addition of some more silicious ore, or silicious material, with the limestone, to flux it in the furnace.

No. 119—LIMONITE. *Labeled "Limestone Ore, top of hill, Clinton Furnace, Greenup county, Ky."*

A dull, reddish-brown, and yellowish-brown, pretty compact limonite; adheres firmly to the tongue. Powder, dirty yellowish-brown color.

| | | |
|---|---|---|
| Specific gravity, | | 2.811 |
| Composition, dried at 212° F.— | | |
| Oxide of iron, | 39.90 | = 28.48 per cent. of *Iron*. |
| Alumina, | 3.37 | |
| Carbonate of lime, | 20.87 | |
| Magnesia, | 2.85 | |
| Oxide of manganese, | 2.17 | |
| Phosphoric acid, | .75 | |
| Potash, | .30 | |
| Soda, | .16 | |
| Silica and insoluble silicates, | 20.97 | |
| Combined water, | 8.66 | |
| | 100.00 | |

The air-dried ore lost 1.8 per cent. of *moisture*, when dried at 212° F.

No. 120—CARBONATE OF IRON. *Labeled "Limestone Ore, two to three feet thick, drifted after at the Clinton Furnace, Greenup county, Ky."*

A dark grey, granular ore; yellowish and reddish-ochreous on the exterior; under the lens presents a confused crystalline appearance. Powder of a dirty buff color.

Specific gravity, - - - - - - - - 3.524

Composition, dried at 212° F.—

| | | |
|---|---|---|
| Carbonate of iron, - - - | 65.93 | 37.55 per cent. of *Iron*. |
| Oxide of iron, - - - | 8.63 | |
| Carbonate of lime, - - - | 1.97 | |
| Carbonate of magnesia, - - | 3.34 | |
| Carbonate of manganese, - | 5.03 | |
| Alumina, - - - - | 2.27 | |
| Potash, - - - - - - | .07 | |
| Soda, - - - - - - | .18 | |
| Silica and insoluble silicates, - | 13.17 | |
| | 100.59 | |

No. 121—CARBONATE OF IRON. *Labeled "Blue Ore, under the coal; average one foot thick; from East fork of Little Sandy river, near Lexington and Big Sandy Railroad, three miles from Clinton Furnace, Greenup county, Ky."*

Dark grey color, mottled with lighter and darker; fine granular; under the lens, dark semi-crystalline grains observed, in a light colored cement; adhering slightly to the tongue. Powder of a mouse-grey color.

Specific gravity, - - - - - - - 3.350

Composition, dried at 212° F.—

| | | |
|---|---|---|
| Carbonate of iron, - - | 42.68 | =32.37 per cent. of *Iron*. |
| Oxide of iron, - - - | 17.02 | |
| Carbonate of lime, - - - | 1.68 | |
| Carbonate of magnesia, - - | 1.52 | |
| Carbonate of manganese, - | .71 | |
| Alumina, - - - - | 2.05 | |
| Potash, - - - - - - | .27 | |
| Soda, - - - - - - | .30 | |
| Organic or bituminous matter, | 11.10 | |
| Silica and insoluble silicates, - | 20.66 | |
| Water and loss, - - - | 2.01 | |
| | 100.00 | |

The air-dried ore lost 0.7 per cent. of *moisture*, when dried at 212° F.

From the considerable proportion of bituminous matter contained in this ore, it may be called a *black band* ore. It is the only ore of this variety which has been sent to this laboratory from Greenup county.

### No. 122—FERRUGINOUS LIMESTONE. *Labeled "Green Carbonate of Iron, Clinton Furnace, Greenup county, Ky."*

Compact; fine granular; with sparkling crystalline grains; scarcely adhering to the tongue; interior, handsome bluish-green color; exterior, rich reddish-brown, mixed with some green particles. Powder of a dirty buff color.

Specific gravity, - - - - - - - - 2.934

Composition, (of average specimen,) dried at 212° F.—

| | | |
|---|---|---|
| Oxide of iron, | 24.80 | 25.68 per cent. of *Iron.* |
| Carbonate of iron, | 17.42 | |
| Carbonate of lime, | 32.85 | |
| Carbonate of magnesia, | 6.36 | |
| Carbonate of manganese, | 1.81 | |
| Alumina, | 2.79 | |
| Phosphoric acid, | .60 | |
| Potash, | .11 | |
| Soda, | .17 | |
| Silica and insoluble silicates, | 10.47 | |
| Water and loss, | 2.62 | |
| | 100.00 | |

The air-dried limestone lost 1. per cent. of *moisture*, when dried at 212°.

### No. 123—COAL. *Labeled "Main Coal, with clay parting, Giger's Hill, Catlettsburg, Greenup county, Ky."*

A very pure looking, bituminous coal, of a deep pitch-black color, and strong lustre; a little pyritous matter observed on one of the surfaces; heated over the spirit lamp, it softened and swelled up very much, and the fragments agglutinated into a light spongy coke; seems to be a coking coal.

Specific gravity, - - - - - - - 1.213

Composition, dried at the ordinary temperature—

| | | | |
|---|---|---|---|
| Moisture, - - - - | 4.20 | Total volatile matters, - | 40.00 |
| Volatile combustible matters, - | 35.80 | | |
| Carbon in the coke, - - - | 57.80 | Coke, - - - - | 60.00 |
| Ashes, (yellowish-grey,) - - | 2.20 | | |
| | 100.00 | | 100.00 |

Composition, dried at 212°—

| | |
|---|---|
| Volatile combustible matters, - - - - - | 37.37 |
| Carbon in the coke, - - - - - - - | 60.33 |
| Ashes, - - - - - - - - - - | 2.30 |
| | 100.00 |

The per centage of *sulphur* is .268. The ashes contained about 0.09 per cent. of sulphate of lime. This is evidently a very pure bituminous coal, containing but a small proportion of sulphur, and leaving less than the general average amount of ashes.

No. 124—FIRE-CLAY. *Labeled "No. 1, Fire-clay, below Main Coal, Ashland, Greenup county, Ky."*

A compact light-grey rock, with some discolorations of ochreous, and brown in the crevices and near the surface, from infiltration of oxide of iron; as hard as calcareous spar; not plastic with water until it has been ground to powder; presenting numerous minute spherical cavities, as though it had been full of air-bubbles; adhering to the tongue.

Composition, dried at 212°—

| | |
|---|---|
| Silica, - - - - - - - - - - - - - | 65.74 |
| Alumina, with trace of oxide of iron, - - - - - - | 26.10 |
| Lime, - - - - - - - - - - - - - | .72 |
| Magnesia, - - - - - - - - - - - | .73 |
| Potash, - - - - - - - - - - - - - | .56 |
| Soda, - - - - - - - - - - - - - | .14 |
| Water and loss, - - - - - - - - - - - | 6.01 |
| | 100.00 |

No. 125—FIRE-CLAY. *Labeled "No. 2, Fire-clay, below Main Coal, Ashland, Greenup county, Ky."*

An indurated clay, or soft clay-stone, of a dark grey color; barely yielding to the nail; softens down into a plastic mass when placed in water; burns white.

Composition, dried at 212° F.—

| | |
|---|---|
| Silica, | 51.74 |
| Alumina, with trace of oxide of iron, | 33.90 |
| Lime, | .62 |
| Magnesia, | .73 |
| Potash, | .88 |
| Soda, | .31 |
| Water, organic matter and loss, | 11.82 |
| | 100.00 |

## HENDERSON COUNTY.

### No. 126—Soil. *Labeled "Soil, four miles south of Henderson, Henderson county, Ky."*

Of a light mouse color, containing some fragments of charcoal; washed very carefully with water it left about 86. per cent. of very fine sand; 1,000 grains, dried at the ordinary temperature, digested in water containing carbonic acid gas, as previously described, gave up more than 7. grains of *solid extract*, dried at 212°. This, treated with pure water, left of *insoluble matter*, 5.582 grains, having the following composition, viz:

| | |
|---|---|
| Silica, | .197 |
| Carbonate of lime, | 3.615 |
| Carbonate of magnesia, | 1.097 |
| Carbonate of manganese, | .556 |
| Alumina, oxide of iron, and trace of phosphates, | .117 |

The matters dissolved in the water, weighed when dried at 212°—1.511 grains; when ignited in a platinum capsule, it lost, with a smell of burnt horn,

| | |
|---|---|
| Organic and volatile matters, | 0.900 |
| The residue contained— | |
| Carbonate of lime, | .197 |
| Carbonate of magnesia, | .279 |
| Alumina, oxide of iron, and trace of phosphates, | .017 |
| Potash, | .083 |
| Soda, | .035 |

This soil contains a remarkably large proportion of its *essential* ingredients, in a *soluble* condition. One thousand grains of the air-dried soil lost 2.04 per cent. of *moisture*, when dried at 300° F.; and was found to contain the following ingredients, viz:

| | |
|---|---|
| Organic and volatile matters, | 5.080 |
| Carbonate of lime, | 1.254 |
| Carbonate of magnesia, | .447 |
| Carbonate of manganese, a trace. | |
| Alumina, oxide of iron, and a trace of phosphates, | 3.490 |
| Potash, | .085 |
| Soda, | .034 |
| Silica and insoluble silicates, | 89.670 |
| | 100.000 |

This soil contains more than the usual proportion of carbonate of lime, but it is not very rich in the alkalies.

### HICKMAN COUNTY.

### No. 127—WHITE EARTH. *Labeled "Part of the White Deposit at the Iron Banks, Columbus, Hickman county, Ky."*

A nearly white, (with a slight tint of grey,) fine granular soft mass, easily crushed with the fingers to a fine granular powder.

Composition, dried at 212°—

| | |
|---|---|
| Silica and insoluble silicates, | 90.99 |
| Alumina, oxide of iron, and a trace of phosphate, | 3.60 |
| Carbonate of lime, | .90 |
| Carbonate of magnesia, | 4.35 |
| Potash, | .07 |
| Soda, | .02 |
| Loss, | .07 |
| | 100.00 |

The air-dried earth lost 1.6 per cent. of *moisture*, when dried at 212° F.

### No. 128—SOIL. *Labeled "White Soil of Bayou de Chienne, at Moscow, Hickman county, Ky., (quarternary formation.")*

A light grey soil, almost white, containing a proportion of rounded particles of clear quartz, and some irregular concretions containing peroxide of iron.

The air-dried soil lost 2.3 per cent. of *moisture*, when dried at 350°.

One thousand grains of the air-dried soil, treated with water containing carbonic acid, in the manner previously described, gave up in solution only 0.27 grains of *solid extract*, which was found to have the following *composition*, viz:

---

*See Appendix for the proportion of phosphoric acid in this and the other soils.

| | |
|---|---|
| Organic and volatile matters, | .08 |
| Carbonate and phosphate of lime, and carbonates of magnesia and iron, | .11 |
| Alkaline salts, (containing .005 potash,) | .04 |
| Silica, | .04 |
| | 0.27 |

The *composition* of this soil, dried at 350°, is as follows:

| | |
|---|---|
| Organic and volatile matters, | 2.00 |
| Oxide of iron and alumina, | 6.00 |
| Carbonate of lime, | 1.15 |
| Magnesia, | .16 |
| Oxide of manganese, | .17 |
| Phosphoric acid, (.54 phosphate of lime,) | .19 |
| Potash, | .17 |
| Soda, | .02 |
| Silica and insoluble silicates, | 90.57 |
| | 100.43 |

Washed carefully with water, this soil left about 79. per cent. of very fine, nearly white sand, containing small rounded particles of hyaline and milky quartz, and of a ferruginous mineral.

This soil being rather deficient in alumina and oxide of iron, has but a small power to hold organic matter in combination.

### No. 129—WHITE EARTH. *Labeled, "Base of Chalk Banks, two miles below Columbus, Hickman county, Ky."*

Appearance like that of a dried clay; color, light grey; rather harsh feel; adheres to the tongue. Dried at 212° it lost 5. per cent. of *moisture.*

Composition, dried at 212°—

| | |
|---|---|
| Organic and volatile matters, | 4.80 |
| Oxide of iron and alumina, | 8.65 |
| Carbonate of lime, | 1.25 |
| Carbonate of magnesia, | .26 |
| Carbonate of manganese, a trace. | |
| Phosphoric acid, a trace. | |
| Potash, | .52 |
| Soda, | .30 |
| Silica and insoluble silicates, | 84.04 |
| Loss, | .18 |
| | 100.00 |

## HOPKINS COUNTY.

### No. 130—LIMONITE. *Labeled "Red Ochreous Iron Ore, Bunt's Gap, near Alfred Townes', Hopkins county, Ky."*

A soft, porous mass, soiling the fingers, of red, yellow, and brownish ochreous matter. Powder of dirty orange-red color.

Composition, dried at 212° F.—

| | | |
|---|---|---|
| Oxide of iron, | 58.75 | = 41.14 per cent. of *Iron*. |
| Alumina, | 4.10 | |
| Carbonate of lime, | .10 | |
| Sulphur, | .15 | |
| Traces of magnesia, manganese, and phosphoric acid. | | |
| Silica and insoluble silicates, | 26.50 | |
| Combined water and loss, | 10.40 | |
| | 100.00 | |

The air-dried ore lost 3.2 per cent. of *moisture,* when dried at 212° F.

### No. 131—LIMONITE. *Labeled "Iron Ore, above the Black Band, head waters of Stewart's creek, Hopkins county, Ky."*

A fragment of a nodular mass, of a lamellar structure; compact; color, yellowish-brown; adheres to the tongue.

Specific gravity, - - - - - - - 2.83

Composition, dried at 212° F.

| | | |
|---|---|---|
| Oxide of iron, | 52.16 | = 36.52 per cent. of *Iron*. |
| Alumina, | 7.70 | |
| Magnesia, | .23 | |
| Potash, | .23 | |
| Soda, | .23 | |
| Phosphoric acid, lime, and oxide of manganese, traces. | | |
| Silica and insoluble silicates, | 26.70 | |
| Combined water, | 11.80 | |
| Loss, | .95 | |
| | 100.00 | |

The air-dried ore lost 1.7 per cent. of *moisture,* when dried at 212° F.

No. 132—Impure Bituminous Carbonate of Lime. *Labeled "Black Band Iron Ore, head waters of Stewart's creek, Townes & Kirkwell's, Hopkins county, Ky."*

A dull olive-black, hard mineral; fracture even; earthy.

Specific gravity, - - - - - - - - 2.56

Composition, dried at 212° F.—

| | | |
|---|---|---|
| Carbonate of lime, | 39.90 | |
| Carbonate of magnesia, | 20.50 | |
| Carbonate of manganese, | 1.02 | |
| Carbonate of iron, | 11.71 | = 6.64 per cent. of *Iron*. |
| Oxide of iron, | 2.22 | |
| Alumina, | .60 | |
| Phosphate of lime, | 5.23 | |
| Potash, | .17 | |
| Soda, | .09 | |
| Bituminous matters, | 6.05 | |
| Silica and insoluble silicates, | 12.41 | |
| Loss, | .10 | |
| | 100.00 | |

The air-dried mineral lost 0.5 per cent. of *moisture*, when dried at 212° F.

Notwithstanding the promising appearance of this mineral, it proves, on analysis, to be worthless as an iron ore—for its considerable proportion of phosphate of lime renders it improper for use, even as a flux to richer ores of iron.

No. 133—Impure Bituminous Carbonate of Iron. *Labeled "Black Band Iron Ore, head waters of Sugar creek, Townes & Kirkwell, Hopkins county, Ky."*

A dull olive-black, hard mineral; not quite so dark in color as the preceding; with an even earthy fracture; weathered exterior surface, yellowish-nmber color.

Specific gravity, - - - - - - - 2.613

Composition, dried at 212° F.—

| | |
|---|---|
| Carbonate of lime, - - - | 40.09 |
| Carbonate of magnesia, - - | 22.17 |
| Carbonate of manganese, - | .28 |
| Carbonate of iron, - - - | 7.32 |
| Oxide of iron, - - - | 3.53 |
| Phosphate of lime, - - - | 2.24 |
| Alumina, - - - - - | .17 |
| Potash, - - - - - - | .21 |
| Soda, - - - - - - | .14 |
| Bituminous matter, - - - | 7.25 |
| Silica and insoluble silicates, - | 16.60 |
| | 100.00 |

The air-dried powder lost 0.6 per cent. of *moisture,* when dried at 212° F.

This resembles the preceding in composition and properties.

No. 134—IRON ORE. *Labeled "Head waters of Stewart's creek, near the Black Bank, (productive ore?) Hopkins county, Ky."*

A porous, fine granular, light dove-grey colored rock; resembling impure limestone; adheres to the tongue; weathered surface ochreous. Powder, light yellowish-grey color.

Specific gravity, - - - - - - - - - 2.948

Composition, dried at 212° F.—

| | | |
|---|---|---|
| Oxide of iron, - - - | 25.08 | = 25.30 per cent. of *Iron.* |
| Carbonate of iron, - - - | 17.84 | |
| Carbonate of lime, - - - | 5.97 | |
| Carbonate of magnesia, - - | 7.30 | |
| Carbonate of manganese, - | 1.20 | |
| Alumina, - - - - - | 1.00 | |
| Phosphoric acid, - - - - | .36 | |
| Potash, - - - - - - | .20 | |
| Soda, - - - - - - | .09 | |
| Bituminous matters, - - | 2.51 | |
| Silica and insoluble silicates, - | 34.65 | |
| Water and loss, - - - | 3.81 | |
| | 100.00 | |

The air-dried powder lost 1. per cent. of *moisture,* when dried at 212° F.

Not a very rich ore, but not too poor to be smelted with advantage —especially to mix with richer mineral.

No. 135—COAL. *Labeled "Wright's Mountain Coal, Townes & Kirkwell, Hopkins county, Ky."*

A very pure looking, soft, and friable coal; not soiling the fingers; some portions having a coarse granular fracture, others flat conchoidal; no appearance of pyrites or other impurities. Small fragments heated over the spirit lamp softened, swelled up, and agglutinated, leaving a spongy coke. It appears to be a coking coal.

Specific gravity, - - - - - - - 1.288

Composition, dried at the ordinary temperature—

| | | | |
|---|---|---|---|
| Moisture, - - - - | 7.20 | Total volatile matters, - | 41.40 |
| Volatile combustible matters, - | 34.20 | | |
| Carbon in the coke, - - - | 56.30 | Moderately dense coke, - | 58.60 |
| Ashes, (dark grey,) - - | 2.30 | | |
| | 100.00 | | 100.00 |

Composition, dried at 212° F.—

| | |
|---|---|
| Volatile combustible matters, - - - - - | 36.86 |
| Carbon in the coke, - - - - - - - | 60.67 |
| Ashes, - - - - - - - - - - | 2.47 |
| | 100.00 |

The per centage of *sulphur* is 0.106. The ashes contain no appreciable quantity of sulphate of lime.

No. 136—COAL. *Labeled "Robinson's Coal, Clear creek, one-half mile west of railroad, Hopkins county, Ky."*

A soft coal; easily broken; of a pitch-black color; surface and fissure stained with oxide of iron and gypsum; and shows iridescent colors; heated over the spirit-lamp, it softens and swells up; probably a coking coal.

Specific gravity, - - - - - - - - 1.272

Composition, dried at the ordinary temperature—

| | | | |
|---|---|---|---|
| Moisture, - - - - | 4.40 | Total volatile matters, - | 45.50 |
| Volatile combustible matters, - | 41.10 | | |
| Carbon in the coke, - - - | 51.10 | Moderately dense coke, - | 54.50 |
| Ashes, (reddish-grey,) - - | 3.40 | | |
| | 100.00 | | 100.00 |

Composition, dried at 212° F.—

| | |
|---|---|
| Volatile combustible matters, - - - - | 42.991 |
| Carbon in the coke, - - - - - - | 53.452 |
| Ashes, - - - - - - - - - - | 3.557 |
| | 100.000 |
| The per cent. of *sulphur* is, - - - - | 1.560 |

The ashes contained a trace of sulphate of lime.

No. 137—Coal. *Labeled "Pond River Coal, under the bridge, near McNary's, Hopkins county, Ky."*

Easily broken; coated in the fissures with ochreous matter; cross fracture, pretty pure pitch-black, and lustrous; heated over the spirit-lamp, it decrepitated considerably; softened and swelled up very much into a spongy coke; probably a coking coal.

Specific gravity, - - - - - - - - 1.297

Composition, dried at the ordinary temperature—

| | | | |
|---|---|---|---|
| Moisture, - - - - | 5.10 | Total volatile matters, - | 40.30 |
| Volatile combustible matters, - | 35.20 | | |
| Carbon in the coke, - - - | 53.50 | Coke, rather hard, - - | 59.70 |
| Ashes, (dark brick-red,) - - | 6.20 | | |
| | 100.00 | | 100.00 |

Composition, dried at 212° F.—

| | |
|---|---|
| Volatile combustible matters, - - - - | 37.09 |
| Carbon in the coke, - - - - - - | 56.38 |
| Ashes, - - - - - - - - - - | 6.53 |
| | 100.00 |
| The per centage of *sulphur* is, - - - | 1.122 |

The ashes containing 0.13 per cent. of sulphate of lime.

No. 138—Soil. *Labeled "Soil and Sub-soil, Captain Davis' farm, Hopkins county, Ky., (Coal Measures.")*

The dry soil is of a greyish-buff color, (a little more grey than the common post-office paper.) Washed carefully with water it left about 79. per cent. of *very fine sand,* of a dirty-buff color.

Dried at 330° F., the air-dried soil lost 1.86 per cent. of *moisture.*

One thousand grains of the air-dried soil were digested in water containing carbonic acid, like the preceding, but the experiment was lost from the bursting of the cork when it was too late to repeat it.

The composition of this soil, dried at 330° F., is as follows, viz:

| | |
|---|---|
| Organic and volatile matters, | 3.88 |
| Alumina, oxide of iron, and trace of phosphates, | 6.15 |
| Carbonate of lime, | .06 |
| Carbonate of magnesia, | .21 |
| Oxide of manganese, a trace. | |
| Potash, | .10 |
| Soda, | .06 |
| Silica and insoluble silicates, | 89.19 |
| Loss, | .35 |
| | 100.00 |

It cannot be called a very fertile soil.

## LIVINGSTON COUNTY.

### No. 139—LIMONITE. *Labeled "Sugar Creek Iron Ore, Hopewell Iron Works, Livingston county, Ky."*

A dark brown limonite, reddish ochreous on the surface; hard enough to strike fire with steel, from the presence of infiltrated silex, which gives it, in some pieces, a brecciated appearance. Powder, brownish-yellow ochre.

Specific gravity, - - - - - - - - - 2.887

Composition, dried at 212° F.—

| | | |
|---|---|---|
| Oxide of iron, | 35.97 | = 25.27 per cent. of *Iron.* |
| Alumina, | .80 | |
| Phosphoric acid, | .73 | |
| Carbonate of lime, | .55 | |
| Magnesia, | .13 | |
| Potash, | .21 | |
| Soda, | .34 | |
| Combined water, | 6.60 | |
| Silica and insoluble silicates, | 54.25 | |
| Loss, | .42 | |
| | 100.00 | |

The air-dried ore lost 1. per cent. of *moisture*, when dried at 212° F.

### No. 140—SOIL. *Labeled "Soil from summit of hill, near Hopewell Furnace, Livingston county, Ky."*

Dry soil, of a buff color. Three pounds of the soil sifted through a seive with two hundred and fifty-six appertures to the inch, left about one ounce of cherty and ferruginous pebbles, of various sizes, from that of a peach kernel down. One thousand grains, digested in water saturated with water containing carbonic acid, as previously described, yielded only 0.453 grains of solid extract; this, dried at 212° F., heated with pure water, left of *insoluble* matter, dried at 212°, 0.183 grains of the following

Composition—

| | |
|---|---|
| Silica, | 0.076 |
| Carbonate of magnesia, | .076 |
| Carbonate of lime, alumina, oxide of iron, &c., | .031 |

The portion dissolved by the water weighed, when dried at 212°, 0.270 grains Ignited in a platinum capsule it lost, of

| | |
|---|---|
| Organic and volatile matters, | 0.173 |

The fixed residue consisted of—

| | |
|---|---|
| Carbonate of lime, | .027 |
| Carbonate of potash, | .036 |
| Carbonate of soda, | .030 |
| Carbonate of magnesia, &c., &c., | .004 |

The composition of this *soil* was found to be as follows, dried at 300° F.

| | |
|---|---|
| Organic and volatile matters, | 3.240 |
| Carbonate of lime, | .037 |
| Carbonate of magnesia, | .405 |
| Alumina, oxide of iron, and trace of phosphates, | 9.770 |
| Potash, | .108 |
| Soda, | .200 |
| Silica and insoluble silicates, | 85.830 |
| Carbonate of manganese, | .410 |
| | 100.000 |

The air-dried soil lost 3.76 per cent. of *moisture*, when dried at 300° F.

The burnt soil has a handsome dark orange or salmon color. Imperfectly washed, it left fine sand, mixed with small rounded fragments of silicious minerals, like semi-opal, chalcedony, &c., &c.

### LOGAN COUNTY.

No. 141—SOIL. *Labeled "Soil, southern part of Logan county, Ky., ten miles from Franklin, on the road from Keysburg. (Sub-carboniferous formation.)"*

The dry soil is of a light Scotch snuff color. Carefully washed with water it left about 69. per cent. of very fine sand, of a dirty buff color, containing small beautifully rounded particles of quartz, clear, milky, and reddish, with small particles of a ferruginous mineral.

One thousands grains of the air-dried soil digested in water containing carbonic acid, yielded 1.37 grains of *solid extract*, which had the following composition, viz:

| | |
|---|---|
| Volatile and organic matters, | 0.62 |
| Silica, | .05 |
| Oxide of iron, alumina, and trace of phosphates, | 1.77 |
| Carbonate of lime, | .33 |
| Oxide of manganese, | .18 |
| Potash, | .02 |

The air-dried soil lost 2.3 per cent. of *moisture*, when dried at 300° F., and had the following *composition*, viz:

| | |
|---|---|
| Organic and volatile matters, | 3.500 |
| Oxide of iron and alumina, | 5.160 |
| Carbonate of lime, | .196 |
| Carbonate of magnesia, | .118 |
| Carbonate of manganese, | .119 |
| Phosphate of lime, | .045 |
| Potash, | .181 |
| Soda, | .171 |
| Silica and insoluble silicates, | 90.060 |
| Loss, | .450 |
| | 100.00 |

### LYON COUNTY.

### No. 83—LIMONITE. *Labeled "Iron Ore, Chandler Bank, Kelly's, Suwanner Furnace, Lyon county, Ky."*

A hard, dark reddish-brown limonite, hard enough to scratch glass; very compact; in curved layers; exterior surface, reddish and yellowish ochreous; powder of a brownish-yellow ochre color.

Specific gravity, - - - - - - - 3.538

Composition, dried at 212° F.—

| | | |
|---|---|---|
| Oxide of iron, | 71.74 | = 50.24 per cent. of *Iron*. |
| Alumina, | 1.40 | |
| Phosphoric acid, | .96 | |
| Potash, | .42 | |
| Soda, | .44 | |
| Combined water, | 9.34 | |
| Silica and insoluble silicates, | 15.70 | |
| Traces of oxide of manganese, magnesia and lime. | | |
| | 100.00 | |

The air-dried ore lost 0.7 per cent. of *moisture*, when dried at 212° F.

A very rich silicious iron ore; probably not as easily reduced as the softer and more porous ores.

No. 143—LIMESTONE. *Labeled "Iron Ore, Backster's Bank, Kelly's Furnace, Lyon county, Ky."*

A hard limonite.

| | | |
|---|---|---|
| Specific gravity, - - - - - - - - | | 3.37 |
| Composition, dried at 212° F.— | | |
| Oxide of iron, - - - | 71.50 | = 50.07 per cent. of *Iron*. |
| Alumina, - - - - | 2.30 | |
| Magnesia, - - - - | .15 | |
| Potash, - - - - - | .05 | |
| Soda, - - - - - - | .09 | |
| Combined water, - - - | 10.40 | |
| Silica and insoluble silicates, - | 15.40 | |
| Loss, - - - - - - | .11 | |
| Traces of lime, oxide of manganese, and phosphoric acid. | | |
| | 100.00 | |

The air- dried ore lost 1.1 per cent. of *moisture* when dried at 212°.

No. 144—LIMONITE. *Labeled "Hydrated Brown Oxide of Iron, Alexander's, five miles from Paducah, Blandville road, McCracken county, Ky."*

A hard, fine granular limonite; portion of a large piece in curved layers; color, dark purplish-brown; exterior of layers bright ochreous.

| | | |
|---|---|---|
| Specific gravity, - - - - - - | | 3.65 |
| Composition, dried at 212° F.— | | |
| Oxide of iron, - - - | 83.80 | = 58.68 per cent. of *Iron*. |
| Alumina, - - - - | .60 | |
| Oxide of manganese, - - | .50 | |
| Potash, - - - - - - | .13 | |
| Soda, a trace. | | |
| Magnesia, a trace. | | |
| Phosphoric acid, - - - | 0.07 | |
| Combined water, - - - | 8.30 | |
| Silica and insoluble silicates, - | 6.60 | Of which 5. Silica, |
| | 100.00 | |

### MUHLENBURG COUNTY.

No. 145—LIMONITE. *Labeled "Iron Ore, Haws' ridge, one and a half miles from Greenville, Muhlenburg county, Ky."*

A portion of a nodular mass, of a greyish-reddish-brown color; rough earthy fracture; adheres to the tongue.

| | | |
|---|---|---|
| Specific gravity, | | 2.571 |
| Composition, dried at 212° F.— | | |
| Oxide of iron, | 48.70 | = 34.10 per cent. of *Iron*. |
| Alumina, | 2.70 | |
| Lime. | .05 | |
| Magnesia, | .58 | |
| Phosphoric acid, | .31 | |
| Oxide of manganese, | .08 | |
| Potash, | .36 | |
| Soda, | .12 | |
| Combined water, | 11.20 | |
| Silica and insoluble silicates, | 35.90 | |
| | 100.00 | |

The air-dried ore lost 2.2 per cent. of *moisture*, when dried at 212° F.

No. 146—LIMONITE. *Labeled "Jenkins' Ore Bank, four miles south-east of Old Furnace, Muhlenburg county, Ky."*

A porous, yellowish-brown ore, with darker layers. Powder, yellow ochreous.

| | | |
|---|---|---|
| Specific gravity, | | 2.83 |
| Composition dried at 212°— | | |
| Oxide of iron, | 62.20 | = 43.56 per cent of *Iron*. |
| Alumina, | 2.52 | |
| Lime, | .39 | |
| Magnesia, | .25 | |
| Brown oxide of manganese, | 1.30 | |
| Phosphoric acid, | 2.65 | |
| Potash, | .21 | |
| Soda, | .03 | |
| Combined water, | 11.50 | |
| Silica and insoluble silicates, | 19.30 | |
| | 100.35 | |

The air-dried ore lost .3 per cent. of *moisture*, when dried at 212° F.

Its considerable proportion of phosphoric acid injures the value of this ore.

No. 147—LIMONITE. *Labeled "Iron Ore, with Sandy incrustations, Kincheloe's Bluff, Muhlenburg county, Ky.*

A hard, compact, concretionary limonite; specimen of a curved form, as though it is part of a large reniform nodule; the outside covered with sand cemented with oxide of iron; interior of the curved mass with mamillary and conical projections, rising from a comparatively smooth surface; general color, dark reddish-brown; exterior surfaces, reddish and yellowish ochreous.

| | | |
|---|---|---|
| Specific gravity, - - - - - - - | | 3.46 |
| Composition, dried at 212° F.— | | |
| Oxide of iron, - - - | 60.70 | = 42.50 per cent. of *Iron*. |
| Alumina, - - - - | 1.87 | |
| Magnesia, - - - - | .20 | |
| Lime, - - - - - - | .44 | |
| Oxide of manganese, - - | .20 | |
| Phosphoric acid, - - - | .63 | |
| Potash and soda, (not estimated.) | | |
| Combined water, - - - | 11.00 | |
| Silica and insoluble silicates, - | 25.10 | |
| | 100.14 | |

The air-dried ore lost 1.2 per cent. of *moisture*, when dried at 212° F.

A pretty rich iron ore, notwithstanding the sand which is present.

No. 148—BITUMINOUS CARBONATE OF IRON. *Labeled "Clay Iron-stone, between Turner's and Buckner's Old Iron Works, Muhlenburg county, Ky."*

A nodular mass, of a dark drab color; compact; hard; the exterior layers having an ochreous appearance.

Specific gravity, - - - - - - - 3.11

Composition, dried at 212° F.—

| | | |
|---|---|---|
| Carbonate of iron, | 64.87 | =34.18 per cent. of *Iron*. |
| Oxide of iron, | 4.39 | |
| Carbonate of lime, | 3.58 | |
| Carbonate of magnesia, | 4.26 | |
| Carbonate of manganese, | 1.09 | |
| Phosphate of lime, | 2.10 | =0.93 per cent. of phosphoric acid. |
| Alumina, | .67 | |
| Potash, | .23 | |
| Soda, | .28 | |
| Bituminous matter, | 1.40 | |
| Silica and insoluble silicates, | 16.25 | |
| Loss, | .90 | |
| | 100.00 | |

The air-dried powder lost 0.5 per cent. of *moisture*, when dried at 212°.

This very complex ore would, very probably, smelt without the addition of fluxing material; and if the considerable proportion of phosphoric acid present does not injure the quality of the metal, it will yield an iron adapted to the manufacture of steel. It hardly contains enough bituminous matter to entitle it to the name of *Black Band Ore.*

No. 149—BITUMINOUS CARBONATE OF IRON. *Labeled "Black Band, Williams' Landing, Muhlenburg county, Ky."*

Ore of a slaty structure, with layers of dull black and dark drab-grey; pretty hard; earthy fracture; weathered portions ochreous; powder of dark olive-grey or mouse color.

Specific gravity, - - - - - - - - 3.19

Composition, dried at 212° F.—

| | | |
|---|---|---|
| Carbonate of iron, | 62.42 | 32.52 per cent. of *Iron*. |
| Oxide of iron, | 3.38 | |
| Carbonate of lime, | 3.65 | |
| Carbonate of magnesia, | 7.41 | |
| Carbonate of manganese, | 2.49 | |
| Alumina, | .95 | |
| Phosphoric acid, | .10 | |
| Potash, | .23 | |
| Soda, | .12 | |
| Bituminous matter, | 2.41 | |
| Silica and insoluble silicates, | 15.27 | |
| Water and loss, | 1.57 | |
| | 100.00 | |

The air-dried powder lost 0.6 per cent. of *moisture*, when dried at 212°.

Like the preceding, this would probably require no limestone or other fluxing material for smelting it; and containing less phosphoric acid it is probably a more valuable ore, although its proportion of metallic iron is a little less. Ores of this kind may be more economically worked than any others.

No. 150—Bituminous Carbonate of Iron. *Labeled "Shaly Black Band Iron Ore, waters of Battist creek, Muhlenburg county, Ky."*

A hard slaty mineral, of a very dark grey color in the interior of the layers; exterior of a dark reddish-brown; powder, umber color.

| | | |
|---|---|---|
| Specific gravity, | | 2.94 |
| Composition, dried at 212° F— | | |
| Carbonate of iron, | 64.90 | 36.54 per cent. of *Iron*. |
| Oxide of iron, | 7.41 | |
| Carbonate of lime, | 3.25 | |
| Carbonate of magnesia, | 6.57 | |
| Carbonate of manganese, | 1.18 | |
| Alumina, | .60 | |
| Phosphoric acid, | .35 | |
| Potash, | .17 | |
| Soda, | .52 | |
| Bituminous matter, | 7.87 | |
| Silica and insoluble silicates, | 7.07 | |
| Loss, | .11 | |
| | 100.00 | |

The air-dried powder lost 1. per cent. of *moisture*, when dried at 212°.

This is also a very valuable ore, but in consequence of its small proportion of silica, may require the addition of silicious ore, or other silicious material to flux it in the furnace.

No. 151—Bituminous Carbonate of Iron. *Labeled "Black Band Iron Ore, Ford's Well, Muhlenburg county, Ky."*

Nearly black, with striæ of dark umber color; hard; compact; powder of an umber color.

Specific gravity, - - - - - - - - 2.924

Composition, dried at 212°—

| | | |
|---|---|---|
| Carbonate of iron, | 74.46 | 36.80 per cent. of *Iron*. |
| Oxide of iron, | 1.15 | |
| Carbonate of lime, | 2.45 | |
| Carbonate of magnesia, | 4.70 | |
| Carbonate of manganese, | 1.03 | |
| Alumina, | .70 | |
| Phosphoric acid, | .38 | |
| Potash,<br>Soda, | Not estimated. | |
| Bituminous matter, | 7.90 | |
| Silica and insoluble silicates, | 5.95 | |
| Water and loss, | 1.28 | |
| | 100.00 | |

The air-dried powder lost 1. per cent. of *moisture*, when dried at 212°.

This ore very much resembles the next preceding; it contains a little less silicious matter than that.

No. 152—Bituminous Carbonate of Iron. *Labeled "Grey Band, (productive iron ore?) Slate Bank between Turner's and Buckner's Old Iron Works, Muhlenburg county, Ky."*

A hard, dark grey mineral, with darker horizontal striæ; fine granular; powder, mouse-grey color.

Specific gravity, - - - - - - - - 3.218

Composition, dried at 212°.—

| | | |
|---|---|---|
| Carbonate of iron, | 54.32 | 31.17 per cent. of *Iron*. |
| Oxide of iron, | 6.75 | |
| Carbonate of lime, | 3.87 | |
| Carbonate of magnesia, | 2.97 | |
| Carbonate of manganese, | 2.68 | |
| Alumina, | .50 | |
| Phosphoric acid, | .53 | |
| Potash, | .08 | |
| Bituminous matter, | 4.44 | |
| Silica and insoluble silicates, | 21.95 | |
| Water and loss, | 1.91 | |
| | 100.00 | |

The air-dried powder lost 1. per cent. of *moisture*, when dried at 212°.

This would doubtless prove a profitable ore; it would require the addition of a little limestone to flux it in the furnace.

The comparison between the composition of these specimens and that of the *black band* ores of Scotland, will be made in the tabular view to be given at the end of this report.

No. 153—CARBONATE OF IRON. *Labeled "Carbonate of Iron, from the Slate Ore Bank, between Turner's and the Old Furnace, Muhlenburg county, Ky."*

A pretty compact ore; dark grey in the interior, looking like a dark grey limestone; ochreous and reddish on the exterior; powder of a greyish-buff color.

| | | |
|---|---|---|
| Specific gravity, | | 3.289 |
| Composition, dried at 212° F.— | | |
| Carbonate of iron, | 62.59 | 40.26 per cent. of *Iron*. |
| Oxide of iron, | 14.79 | |
| Carbonate of lime, | 2.67 | |
| Carbonate of magnesia, | 4.69 | |
| Carbonate of manganese, | 1.42 | |
| Alumina, | 1.87 | |
| Phosphoric acid, a trace. | | |
| Potash, | .23 | |
| Soda, | .12 | |
| Silica and insoluble silicates, | 8.19 | |
| Water, bituminous matter, and loss | 3.43 | |
| | 100.00 | |

The air-dried powder lost 0.8 per cent. of *moisture*, when dried at 212°

A very good ore which could probably be smelted without any addition of lime.

No. 154—BITUMINOUS CARBONATE OF LIME. *Labeled "Black Band Iron Ore, one and a half miles northwest of Greenville, Muhlenburg county, Ky."*

A dark colored, hard rock, with an even earthy fracture; weathered surfaces drab colored.

Specific gravity, - - - - - - 2.52

Composition, dried at 212° F.—

| | |
|---|---|
| Carbonate of lime, | 85.00 |
| Carbonate of magnesia, | 1.15 |
| Alumina and oxide of iron, | 1.57 |
| Oxide of manganese, a trace, | |
| Phosphoric acid, | .35 |
| Potash, | .38 |
| Bituminous matter, | 3.14 |
| Silica and insoluble silicates, | 7.95 |
| Loss, | .46 |
| | 100.00 |

The dried powder lost 0.6 per cent. of *moisture*, when dried at 212° F.

The specific gravity of this rock is much lower than that of the black band, but its general appearance is very deceptive.

No. 155—SOIL. *Labeled "Soil from the Coal region, north slope of hill in the north part of Muhlenburg county, Ky."*

The dry soil is of a light Scotch snuff color; washed carefully with water it left about 70. per cent. of very fine sand of a dirty buff color, containing a few minute quartz crystals, and some rounded particles of hyaline and milky quartz, and of a ferruginous mineral.

One thousand grains digested with water containing carbonic acid, yielded more than six grains of solid extract, out of which the organic matter was burnt, giving a strong ammoniacal or urinous odor, leaving the residuum still black from the presence of oxide of manganese. The composition of this extract is as follows:

| | |
|---|---|
| Organic and volatile matters, | 1.57 |
| Carbonate of lime, | 4.13 |
| Magnesia, | .46 |
| Oxide of manganese, | .83 |
| Oxide of iron, | .08 |
| Potash, | .54 |
| Soda, | .12 |
| Silica, | .05 |
| Phosphoric acid, (not estimated.) | |

The air-dried soil lost 2.85 per cent. of *moisture*, when dried at 350°

The *composition*, dried at this temperature is as follows:

| | |
|---|---|
| Organic and volatile matters, | 5.80 |
| Oxide of iron and alumina, | 5.05 |
| Phosphate of lime, | .08 |
| Oxide of manganese, | .31 |
| Magnesia, | .54 |
| Carbonate of lime, | 1.07 |
| Potash, | .19 |
| Soda, | .03 |
| Silica and insoluble silicates, | 86.64 |
| Loss, | .29 |
| | 100.00 |

Not very rich in phosphates, nor in alumina and oxide of iron.

No. 156—Coal. *Labeled "(McLean,) Airdrie Coal, below the clay parting, six and three-twelfth feet thick, Muhlenburg county, Ky."*

A pure, soft and friable coal, of a shining pitch-black appearance; fibrous coal between the layers; no appearance of pyrites or other impurities; fragments heated over the spirit-lamp, softened, swelled up and agglutinated into a light cellular coke; probably a good coking coal.

Specific gravity, - - - - - - - - 1.221

Composition, dried at the ordinary temperature—

| | | | |
|---|---|---|---|
| Moisture, | 3.10 | Total volatile matters, | 48.40 |
| Volatile combustible matters, | 45.30 | | |
| Carbon in the coke, | 48.50 | Coke, | 51.60 |
| Ashes, (reddish-grey,) | 3.10 | | |
| | 100.00 | | 100.00 |

Composition, dried at 212° F.—

| | |
|---|---|
| Volatile combustible matters, | 46.749 |
| Carbon in the coke, | 50.052 |
| Ashes, | 3.199 |
| | 100.000 |
| The per centage of *sulphur* is, | 1.35 |

The ashes contained no marked amount of sulphate of lime.

No. 157—Coal. *Labeled "Eade's Coal, two miles and a half south-west of Greenville, Muhlenburg county, Ky."*

A soft, pure pitch-black coal, with fibrous coal, exhibiting vegetable impressions, between the layers; no appearance of pyrites or other impureties, heated over the spirit-lamp, it softened and swelled up a good deal, and left a light coke; probably a good coking coal.

Specific gravity, - - - - - - - 1.260

Composition, dried at the ordinary temperature—

| | | | |
|---|---|---|---|
| Moisture, - - - - | 2.80 | Total volatile matters, | 40.40 |
| Volatile combustible matters, | 37.60 | | |
| Carbon in the coke, - - | 56.10 | Coke, - - - - | 59.60 |
| Ashes, (purplish,) - - | 3.50 | | |
| | 100.00 | | 100.00 |

Composition, dried at 212°—

| | |
|---|---|
| Volatile combustible matters, - - - - - | 38.684 |
| Carbon in the coke, - - - - - - - | 57.716 |
| Ashes, - - - - - - - - - - | 3.600 |
| | 100.000 |

The per centage of *sulphur* is, - - - .654

No appreciable amount of sulphate of lime in the ashes.

No. 158—Coal. *Labeled "Clark's Coal, Pond river, on Princeton and Greenville road, Muhlenburg county, Ky."*

A very friable, dull looking coal; not soiling the fingers; breaking into small fragments; heated over the spirit-lamp it burnt only for a short time with a flame; did not soften nor swell up; and the residuum burnt on the hot iron, after removal from the lamp, like rotten wood.

Specific gravity, - - - - - - - - 1.348

Composition, dried at the ordinary temperature—

| | | | |
|---|---|---|---|
| Moisture, - - - - | 8.70 | Total volatile matters, | 33.30 |
| Volatile combustible matters, | 24.60 | | |
| Carbon in the fixed residuum, | 59.20 | Fixed residue, - | 66.70 |
| Ashes, (nearly white,) - | 7.50 | | |
| | 100.00 | | 100.00 |

Composition, dried at 212° F.—

| | |
|---|---|
| Volatile combustible matters, - - - - | 26.944 |
| Carbon in the fixed residue, - - - - | 64.840 |
| Ashes, - - - - - - - - - | 8.216 |
| | 100.00 |

The per centage of *sulphur* is, - - - .550

## OWSLEY COUNTY.

No. 159—Coal. *Labeled "Todd & Crittenden's Coal, from the Three Forks of the Kentucky river, Owsley county, Ky."*

A good specimen of Kentucky river coal; of a pitch-black color, and considerable lustre; fibrous coal, with vegetable impressions between the layers; over the spirit-lamp it swells up somewhat, but does not agglutinate as much as the Pittsburg coal; a somewhat *dry* bituminous coal, or soft variety of splint coal.

Specific gravity, - - - - - - - 1.295

Composition, dried at the ordinary temperature—

| | | | |
|---|---|---|---|
| Moisture, | 3.40 | Total volatile matters, | 36.80 |
| Volatile combustible matters, | 33.16 | | |
| Carbon in the coke, | 57.10 | Coke, | 63.20 |
| Ashes, (nearly white,) | 6.43 | | |
| | 100.00 | | 100.00 |

Composition, dried at 212° F.—

| | |
|---|---|
| Volatile combustible matters, | 34.575 |
| Carbon in the coke, | 58.765 |
| Ashes, | 6.660 |
| | 100.000 |

The per centage of *sulphur* is, - - - - - .337

From want of sufficient time, this was the only one of the Kentucky coals which was submitted to ultimate or elementary analysis. Burnt in the usual way, in the combustion tube with fused chromate of lead, there were obtained from 5 grains, 12.85 of *carbonic acid*, and 2.48 of water. Deducting the sulphur and ashes, as stated above, the statement of the ultimate composition of this coal is as follows:

Ultimate analysis, dried at 212°, average of six operations—

| *A*—Calculated with the ashes: | | *B*—Calculated without the ashes: | |
|---|---|---|---|
| Carbon, | 69.160 | Carbon, | 74.094 |
| Hydrogen, | 5.360 | Hydrogen, | 5.742 |
| Oxygen, nitrogen, and loss, | 18.483 | Oxygen, nitrogen, and loss, | 19.802 |
| Sulphur, | .337 | Sulphur, | .362 |
| Ashes, | 6.660 | | |
| | 100.000 | | 100.000 |

No. 160—Coal. *Labeled "Cannel Coal from Haddock's Mine, between South and Middle Forks of Kentucky river, Owsley county, Ky."*

A very tough, pitch-black coal; fracture large conchoidal; not soiling the fingers; powder nearly black, with a very slight brownish tinge, like lamp-black; heated over the spirit-lamp, swelled a little and became somewhat porous; burning with a very large clear flame; but did not soften as much as the preceding specimen; burns on the open fire without coking; gives out a great deal of flame.

| | | | |
|---|---|---|---|
| Specific gravity, | 1.211 | | |
| Composition, dried at the ordinary temperature— | | | |
| Moisture, | 1.10 | Total volatile matters, | 50.00 |
| Volatile combustible matter, | 48.90 | | |
| Carbon in the coke, | 47.00 | Coke, | 50.00 |
| Ashes, (buff colored,) | 3.00 | | |
| | 100.00 | | 100.00 |

| | |
|---|---|
| Composition, dried at 212° F.— | |
| Volatile combustible matters, | 49.444 |
| Carbon in the coke, | 47.523 |
| Ashes, | 3.033 |
| | 100.000 |
| The per centage of *sulphur* is only, | 0.241 |

The ashes contain about 0.236 per cent. of *sulphate of lime.*

One of the best specimens of cannel coal. We hope to be able at a future time to examine these coals more thoroughly, as well as to pass in review the rich variety of coals to be found in the eastern coal fields of Kentucky.

## SIMPSON COUNTY.

No. 161—SOIL. *Labeled "Soil, north part of Simpson county, Ky., three-quarters of a mile from the Warren county line."*

The dry soil is of a snuff color, with a tinge of reddish or lilac; rather darker colored than usual.

Washed with water, about 25. per cent. of fine sand was obtained, the grains of which, under the lens, appeared rounded; some pellucid, others yellow, red and brown.

One thousand grains digested in water containing carbonic acid gave up nearly 3. grains of *solid extract,* dried at 212°.

This treated with pure water left rather more than one-half its weight of *insoluble matter,* which had been dissolved by the carbonic acid; having the following composition, viz:

| | | |
|---|---|---|
| Silica, | 0.120 | |
| Carbonate of lime, | .377 | |
| Carbonate of magnesia, | .916 | |
| Carbonate of manganese, | .025 | |
| Sulphate of lime, | .010 | |
| Alumina, oxide of iron, and a trace of phosphate, | .027 = | 1.475 |

The portion dissolved by the water was dried and the

| | | |
|---|---|---|
| Organic and volatile matters, removed by heat, weighed, | 0.780 | |
| The residue contained, | | |
| Carbonate of lime, | .257 | |
| Carbonate of magnesia, | .132 | |
| Potash, | .064 | |
| Soda, | .037 = | 1.270 |
| Alumina and oxide of manganese, traces. | | |

The air-dried soil lost 2.8 per cent. of *moisture*, when dried at 320°.

The *composition* of the soil is as follows, dried at 320°:

| | |
|---|---|
| Organic and volatile matters, | 5.100 |
| Carbonate of lime, | .194 |
| Carbonate of magnesia, | .307 |
| Carbonate of manganese, | .235 |
| Alumina, oxide of iron, and trace of phosphates, | 6.510 |
| Potash, | .131 |
| Soda, | .070 |
| Silica and insoluble silicates, | 87.470 |
| | 100.017 |

### TODD COUNTY.

No. 162—SUB-SOIL. *Labeled "Red Clay Sub-soil, Todd county, Ky.; the same prevalent through a large district of the sub-carboniferous limestone formation. How much oxide of iron?"*

Color, dull reddish-yellow. The *composition* is as follows:

| | |
|---|---|
| Organic and volatile matters, | 4.10 |
| Oxide of iron, alumina, and trace of phosphates, | 5.80 |
| Carbonate of lime, | 1.42 |
| Carbonate of magnesia, | .24 |
| Potash, | .11 |
| Soda, | .03 |
| Silica and insoluble silicates, | 88.30 |
| | 100.00 |

The air-dried soil lost 2. per cent. of *moisture*, when dried at 212°.

No. 163—SOIL. *Labeled "Soil, with admixture of sub-soil, taken opposite a large plantation amongst oak timber, about 2 miles from the crossing of the Elk fork of Red River, between Haydensville and Hollingsworth Mill, Todd county, Ky."*

Dry soil of a greyish-brown color, with a tinge of red. Washed with water it left only *very fine sand.* One thousand grains digested in water containing carbonic acid as before described, yielded 1.093 grs. of *solid extract*, dried at 212°. This, treated with pure water, left of *insoluble matter*, which had been dissolved by the carbonic acid, the following ingredients:

| | | |
|---|---|---|
| Silica, - - - - - - - - - - | 0.160 | |
| Carbonate of lime, - - - - - - - | .257 | |
| Carbonate of magnesia, - - - - - - | .151 | |
| Carbonate of manganese, - - - - - - | .341 | |
| Alumina, oxide of iron, and trace of phosphates, - | .037 | |
| Sulphate of lime and loss, - - - - - - | .167 = | 1.113 |

The *soluble portion*, ignited in a platinum capsule, lost of,

| | | |
|---|---|---|
| Organic and volatile matters, - - - - - - - - - | | 0.280 |

And the fixed residue consisted of,

| | | |
|---|---|---|
| Carbonate of lime, - - - - - - - | .037 | |
| Carbonate of magnesia, - - - - - - | .007 | |
| Potash, - - - - - - - - - - | .067 | |
| Soda, - - - - - - - - - - - - | .033 | |
| Alumina, oxide of iron, trace of phosphates, and loss, | .156 = | 580 |

The air-dried soil lost 2.8 per cent. of *moisture*, when dried at 212°.

Its *composition* is as follows:

| | |
|---|---|
| Organic and volatile matters, - - - - - - - - - | 4.180 |
| Carbonate of lime, - - - - - - - - - | .194 |
| Carbonate of magnesia, - - - - - - - - - | .475 |
| Carbonate of manganese, - - - - - - - - | .114 |
| Alumina, oxide of iron, and trace of phosphates, - - - | 6.830 |
| Potash, - - - - - - - - - - - - - | .178 |
| Soda, - - - - - - - - - - - - - | .095 |
| Silica and insoluble silicates, - - - - - - - | 87.830 |
| Sulphate of lime and loss, - - - - - - - - | .104 |
| | 100.00 |

### TRIMBLE COUNTY.

No. 164—LIMESTONE. *Labeled "Marble, Corn Creek, on the Ohio river opposite to Marble Hill, the quarry of Conchitie Marble of Messrs. Wm. W. Dean and Co., in Jefferson county, Indiana, thirty miles above Louisville; supposed to be of the same kind. Quarry of Dr. Hopson."*

This rock is of a warm, or drab-grey color, presenting a granular crystalline structure, containing many fragments of shells, especially of *Murchisonia bellicincta;* and very small portions of coral—probably *Chaetetes lycoperdon*—cemented by pure minute crystals of calcareous spar, which form the principal mass of the rock. Some of the fragments of fossils have a pink color; the cavities of some of the shells are filled with beautifully clear, colorless calcareous spar; in others the spar filling them is colored of a pinkish-brown, or flesh color by oxide or carbonate of iron; which appears occasionally in the stone in small spots and patches. On one of the specimens there is the fragment of a bi-valve shell, and in another two portions of Orthoceras. The weathered surfaces are remarkably even, and free from fissures, and indicate great durability. A piece of the rock, rubbed down with sand, &c., received a very good polish; a few fine cracks only traverse the surface, in appearance like the sutures on a skull, which doubtless are the results of the long exposure to the atmospheric influences of this outside portion of the bed, and will not, probably, be found in the interior of the stratum, where moisture and a uniform temperature have been preserved.

Compared with two slabs of the *Conchitic marble*, from the quarry of the Messrs. Deans, at the marble-yard of Mr. Pruden, of this city, it was found, by all appearances, to be identical. (The face of one of these slabs, however, which seemed to be course grained, was studded with branching specimens of the *Chaetetes lycoperdon*.)

*Specific gravity* of this marble was found to be 2.704; that of the Dean's as reported by Dr. Owen, 2.683.

A fragment of an irregular tetrahedral form, weighing 314.8 grains, (nearly 20.38 grammes,) was allowed to remain in water for about an hour, when having been wiped dry with blotting paper, and weighed, it was found to have gained, by imbition of water, 1.5 grains,=0.47 per cent. At the end of an hours exposure, in a dry room, at the temperature of 71.5° F., it had lost one-third of this water; next morning it retained only 0.1 grains of the water.

Its *composition* was found to be as follows, viz: (For comparison, the results of the analyses of two varieties of Dean's *Conchitic marble*, by Dr. D. D. Owen, are placed in adjoining columns.)

| | | Dean's marble, two varieties. | |
|---|---|---|---|
| Carbonate of lime, | 96.03 | 89.68 | 81.60 |
| Carbonate of magnesia, | .74 | 3.80 | 10.50 |
| Carbonate of iron, | 1.09 | 2.30 | 5.28 |
| Phosphate of lime, | 1.19 | .85 | .90 |
| Alumina, | .16 | 1.00 | .52 |
| Insoluble earthy matter, (silica, &c.,) | .66 | 2.00 | .20 |
| Moisture, | .06 | .10 | .10 |
| Oxide of manganese, | a trace, | a trace, | a trace. |
| Loss, | .07 | .27 | .90 |
| | 100.00 | 100.00 | 100.00 |

It would appear from the above comparison of the composition of this specimen, with that of those analyzed by Dr. Owen, from the Indiana quarry, that this is even purer than those. It has also a slightly higher specific gravity. There can be no doubt that it will prove an equally good and handsome building material.

The following remarks by Dr. Owen, on the Conchitic marble of Indiana, will doubtless apply with a perfect fitness to this marble also: "Taking into consideration the properties and chemical composition of the rock of Marble Hill, as ascertained by the preceding investigations, and a careful inspection of the quarries, as well as the rock in its natural position along the face of the bluff, I have no hesitation in pronouncing it the *best* and *most beautiful* material for constructions and ornamental purposes that has come within my notice from any western locality." (A *Geological* report on the Marble Hall Quarry, &c., &c., by David Dale Owen, M. D., 1853.)

Whether the more recent geological explorations in Kentucky, of its worthy Principal Geologist, will enable him to modify his opinion, in the above relation, will be seen in his forthcoming report on the geology of this State.

### TRIGG COUNTY.

No. 165—Soil. *Labeled "Soil, for seven inches, in cherty bed of sub-carboniferous limestone system, Barren oak land, four miles south of Cadiz, Trigg county, Ky."*

Color of the dried soil, dark greyish-buff; washed with water it left a large proportion of *very fine sand* of a dirty buff color.

One thousand grains of the air-dried soil digested, as before described, in water containing carbonic acid, yielded rather more than one grain of *solid extract*, dried at 212°. This, treated with water, left of *insoluble matters* which had been dissolved by the carbonic acid, as follows:

| | | |
|---|---|---|
| Silica, - - - - - - - - - - - | 0.147 | |
| Carbonate of lime, a trace. | | |
| Carbonate of magnesia, - - - - - - | .195 | |
| Carbonate of manganese, - - - - - - | .054 | |
| Alumina, oxide of iron, and a trace of phosphates, | .017 | — .413 |

The *soluble* portion dried and ignited, lost of

| | | |
|---|---|---|
| Organic and volatile matters, - - - - | 0.400 | |

The fixed residue consisted of—

| | | |
|---|---|---|
| Carbonate of lime, - - - - - - - | .047 | |
| Carbonate of magnesia, - - - - - - | .069 | |
| Carbonate of manganese, - - - - - - | .022 | |
| Alumina, oxide of iron, and a trace of phosphates, - | .017 | |
| Potash and soda, - - - - - - - - | .031 | |
| Loss, - - - - - - - - - - - | .044 | — .630 |

The air-dried soil lost 1.74 per cent. of *moisture*, when dried at 300°.

Its *composition* is as follows:

| | |
|---|---|
| Organic and volatile matters, - - - - - - - | 3.28 |
| Carbonate of lime, - - - - - - - - - - | .034 |
| Carbonate of magnesia, - - - - - - - - - | .195 |
| Carbonate of manganese, - - - - - - - - - | .195 |
| Alumina, oxide of iron, and trace of phosphates, - - - | 3.690 |
| Potash, - - - - - - - - - - - - - | .096 |
| Soda, - - - - - - - - - - - - - | .022 |
| Silica and insoluble silicates, - - - - - - - | 92.310 |
| Loss, - - - - - - - - - - - - - | ·178 |
| | 100.00 |

### UNION COUNTY.

No. 166—COAL. *Labeled "Coal from Casey's Mine, near Caseyville, Union county, Ky."*

A pure looking, glossy black, soft bituminous coal, of a lamellar structure; no appearance of pyrites or other impurities. Heated over the spirit-lamp it softened and swelled up very much, and agglutinated into a light spongy coke. Seems a good coking coal.

| | | | |
|---|---|---|---|
| Specific gravity, - - - - - - - | | | 1.312 |
| Composition, dried at 212° F.— | | | |
| Volatile combustible matters, - | 40.70 | | |
| Carbon in the coke, - - - | 52.30 | Coke, - - - - - | 59.30 |
| Ashes, (purplish-grey,) - - | 7.00 | | |
| | 100.00 | | |
| The per centage of sulphur is, - - - - | | | 0.88 |

The air-dried coal lost only 0.4 per cent. of *moisture,* when dried at 212°.

No. 167—FIRE CLAY. *Labeled "Fire-clay from Casey's Mines, Union county, Ky."*

A soft clay-stone, or indurated clay; what is sometimes called "horseback" by the coal-diggers; irregularly lamellar, of a dark grey color, with some black vegetable impressions; exhibits a few minute scales of mica.

| Composition, dried at 212°— | |
|---|---|
| Silica, - - - - - - - - - - - - | 73.00 |
| Alumina, - - - - - - - - - - - | 17.60 |
| Oxide of iron, - - - - - - - - - - | 3.00 |
| Carbonate of lime, - - - - - - - - - | .60 |
| Potash and soda, - - - - - - - - - | .10 |
| Water, organic matter and loss, - - - - - - - | 5.70 |
| | 100.00 |

A very good fire-clay.

### WARREN COUNTY.

No. 168—SOIL. *Labeled "Soil west part of Warren county, Ky."*

Dry soil of a dirty powdered cinnamon color; contained a few fragments of radiated and milky quartz, (too large to go through the seive of 256 apertures to square inch.) By washing with water obtained about 60. per cent. of very fine sand, of a cinnamon color, containing a few small scales of mica. One thousand grains of the air-dried soil, digested in water containing carbonic acid, as already described, yielded a little more than one grain of *solid extract*, dried at 212°. This, treated with pure water, left of *insoluble matter*, which had been dissolved by the carbonic acid, rather more than half a grain; having the following composition, viz:

| | | |
|---|---|---|
| Silica, | 0.170 | |
| Carbonate of lime, | .137 | |
| Carbonate of magnesia, | .131 | |
| Alumina, oxide of iron, and a trace of phosphates, | .067 | |
| Sulphate of lime, | .010 | 0.515 |

The *soluble matter*, dried and ignited in a platinum capsule lost of

| | | |
|---|---|---|
| Organic and volatile matters, | 0.300 | |

And the fixed residue contained

| | | |
|---|---|---|
| Carbonate of lime, | .077 | |
| Carbonate of magnesia, | .097 | |
| Potash, | .038 | |
| Soda, | .021 | |
| Alumina, &c., a trace. | | .533 |
| In all, | | 1.048 |

The air-dried soil lost 2.18 per cent. of *moisture*, when dried at 212°.

Its *composition* is as follows:

| | |
|---|---|
| Organic and volatile matters, | 2.900 |
| Carbonate of lime, | .094 |
| Carbonate of magnesia, | .350 |
| Carbonate of manganese, | .054 |
| Phosphate of lime, | .221 |
| Alumina and oxide of iron, | 5.129 |
| Potash, | .150 |
| Soda, | .043 |
| Silica and insoluble silicates, | 90.990 |
| Sulphate of lime and loss, | .069 |
| | 100.000 |

It would be improved by a larger proportion of alumina and oxide of iron, which would increase its power of absorbing and retaining the products of animal and vegetable decomposition, gases and vapors.

### PITTSBURG COAL.

For the purposes of comparison with the coals of Kentucky, a specimen of this coal was submitted to examination.

No. 169—COAL. *Labeled "Pittsburg Coal," sent to me from Louisville some years since, and kept in a dry place, (in my cabinet,) ever since.*

A pure looking coal of a pitch-black color and considerable lustre. Heated over the spirit-lamp it softened and swelled up very much, and agglutinated into a very light coke.

Specific gravity, - - - - - - - - 1.291

Composition, dried at the ordinary temperature—

| | | | |
|---|---|---|---|
| Moisture, - - - - | 2.00 | Total volatile matters, | 31.70 |
| Volatile combustible matters, | 29.70 | | |
| Carbon in the coke, - - | 65.30 | Coke, - - - - | 68.30 |
| Ashes, (yellowish-grey,) - | 3.00 | | |
| | 100.00 | | 100.00 |

Composition, dried at 212° F.—

| | |
|---|---|
| Volatile combustible matters, - - - - | 30.003 |
| Carbon in the coke, - - - - - - - | 66.636 |
| Ashes, - - - - - - - - - | 3.061 |
| | 100.000 |

The per centage of *sulphur* is only 0.055 in the specimen examined, which is probably a selected specimen.

# I. IRON ORES.

## (*a*) LIMONITES.

(*Showing the per centage of each ingredient.*)

| Number in report. | Peroxide of iron | Carbonate of iron. | Per centage of iron. | Alumina. | Lime and carbonate. | Magnesia and carbonate. | Brown oxide of manganese. | Phosphoric acid. | Potash. | Soda. | Silica, &c. | Water. | Sulphur, &c. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 5 | 79.90 | – | 55.95 | 1.10 | 0.10 | 1.53 | 1.80 | – | not es | timt'd | 9.00 | 6.57 | – |
| 11 | 23 20 | 6.28 | 19.24 | 1.95 | 51.35 | 1.53 | 3.41 | 0.24 | 0.23 | 0.18 | 9.67 | 1.96 | – |
| 12 | 71.50 | – | 50.07 | 2.45 | – | 1.03 | 1.37 | – | .34 | .12 | 11.97 | 11.57 | – |
| 13 | 67.40 | – | 47.20 | .87 | .57 | 1.81 | .95 | – | .50 | .16 | 17.57 | 11.55 | – |
| 23 | 39.60 | – | 27.73 | 1.00 | .58 | – | .20 | .67 | not es | tim'td | 51.30 | 6.40 | – |
| 31 | 41.70 | – | 29.20 | 1.25 | – | .20 | .58 | 2.30 | .13 | – | 45.05 | 8.01 | – |
| 32 | 49.69 | – | 34.79 | 2.53 | – | .33 | .45 | .22 | .38 | .11 | 38.35 | 7.68 | – |
| 33 | 60.00 | – | 42.00 | .68 | 20.67 | 3.84 | – | – | .17 | .06 | 4.07 | 10.70 | – |
| 34 | 72.70 | – | 50.90 | 2.00 | – | .37 | .57 | – | .42 | .17 | 13.17 | 11.48 | – |
| 35 | 54.60 | – | 38.23 | Phos.<br>4.55 | 13.85 | – | – | .74 | .36 | .32 | 13.37 | 9.28 | – |
| 36 | 87.00 | – | 60.09 | .60 | – | .82 | .65 | .67 | .30 | .21 | 3.47 | 6.59 | – |
| 44 | 61.18 | 7.48 | 46.51 | 2.27 | 2.15 | carb.<br>2.02 | carb.<br>2.92 | – | .45 | – | 11.23 | 10.29 | – |
| 45 | 68.10 | – | 47.69 | 2.93 | – | .67 | 1.64 | .43 | .54 | .13 | 13.05 | 11.67 | – |
| 46 | 58.90 | – | 41.24 | 4.15 | 3.15 | 2.40 | .97 | – | .58 | .47 | 17.87 | 11.26 | – |
| 54 | 49 45 | – | 34.63 | .45 | 7.35 | 2.58 | 1.15 | 1.53 | .67 | .19 | 25.65 | 10.96 | – |
| 55 | 66.90 | – | 46.85 | 2.65 | – | .33 | .65 | .25 | .27 | .31 | 19.75 | 8.75 | – |
| 56 | 63 50 | – | 44.54 | 3.55 | – | .40 | 1.95 | – | .34 | .17 | 17.95 | 12.05 | – |
| 57 | 60.50 | – | 42.35 | 2.95 | – | .40 | 3.15 | .14 | .19 | .37 | 25.35 | 6.95 | – |
| 58 | 70.30 | – | 49.23 | 2.15 | – | .37 | .75 | – | .17 | .16 | 13.95 | 11.76 | – |
| 59 | 63.20 | – | 44.26 | 1.95 | – | .74 | 1.15 | – | .44 | – | 22.35 | 10.30 | – |
| 69 | 38.50 | – | 26.96 | 3.37 | – | 1.20 | .97 | – | .66 | .10 | 46.95 | 8.25 | – |
| 70 | 68.10 | – | 47.69 | 2.17 | – | .91 | .31 | – | .48 | .07 | 16.25 | 11.51 | – |
| 71 | 26.60 | – | 18.62 | 2.37 | – | .77 | .17 | – | .34 | .17 | 63.90 | 5.68 | – |
| 72 | 51 00 | – | 35.71 | 2.27 | .47 | 1.48 | .97 | – | .52 | .28 | 33.65 | 9.81 | – |
| 73 | 67.50 | – | 47.27 | 2.97 | .97 | 1.62 | 1.32 | – | .38 | – | 14.75 | 12.11 | – |
| 80 | 65 30 | – | 47.82 | 2.65 | 47 | .86 | 1.55 | – | .22 | .10 | 23.67 | 4.93 | – |
| 81 | 76.20 | – | 53.36 | 2.25 | – | 1.86 | 1.00 | – | .33 | .10 | 11.27 | 7.60 | – |
| 82 | 71.90 | – | 50.35 | 1.67 | .27 | 1.13 | 1.35 | .25 | .24 | .06 | 14.17 | 9.22 | – |
| 83 | 80.60 | – | 56.44 | .87 | – | .40 | .77 | – | .21 | .35 | 6.97 | 9.51 | – |
| 93 | 56.50 | – | 39.56 | 2.95 | 7.27 | 2.30 | 1.00 | trace. | 0.26 | 0.11 | 18.27 | 11.34 | – |
| 94 | 62.90 | – | 44.04 | 3.15 | .57 | .68 | trace. | trace. | .32 | .04 | 24.97 | 8.41 | 0.15 |
| 95 | 81.87 | – | 57.33 | .97 | – | .33 | .55 | .23 | .07 | .14 | 3.67 | 12.39 | – |
| 96 | 57.10 | – | 40.03 | 1.65 | 9.37 | 1.49 | .37 | – | .08 | .09 | 20.07 | 9.80 | – |
| 103 | 57.90 | – | 40.53 | 2.77 | – | .72 | .25 | trace | .32 | .10 | 27.67 | 10.03 | – |
| 104 | 13.25 | – | 9.27 | 4.95 | 1 67 | .61 | – | phos l.<br>.90 | not es | tim'td | 74.37 | 4.36 | – |
| 105 | 56.70 | – | 39.70 | 3.75 | – | .63 | .42 | – | .32 | .17 | 25.97 | 12.04 | – |
| 106 | 64.70 | – | 45.31 | .27 | 16 50 | 1.84 | 2 15 | – | .23 | .05 | 6.47 | 7.12 | – |
| 107 | 32.10 | – | 22.48 | 1.47 | – | .33 | – | – | .12 | – | 61.37 | 4.62 | – |
| 117 | 85.16 | – | 59.63 | .84 | – | .59 | .95 | – | .25 | – | 4.57 | 7.64 | – |
| 119 | 39 90 | – | 28.48 | 3.37 | 20.87 | 2.85 | 2.17 | .75 | .30 | .16 | 20.97 | 8.66 | – |
| 130 | 58.75 | – | 41.14 | 4.10 | .10 | – | – | trace. | not es | tim'td | 26.50 | 10.40 | .15 |
| 131 | 52.16 | – | 36.52 | 7.70 | trace. | .23 | trace. | trace· | .23 | .23 | 26.70 | 11.80 | – |
| 139 | 35.97 | – | 25.27 | .80 | .55 | .13 | – | .73 | .21 | .34 | 54.25 | 6.60 | – |
| 142 | 71.74 | – | 50.24 | 1.40 | trace. | trace | trace. | .96 | .42 | .44 | 15.70 | 9.34 | – |
| 143 | 71 50 | – | 50.07 | 2 30 | trace. | .15 | trace. | trace. | .05 | .09 | 15.40 | 10.40 | – |
| 144 | 83.80 | – | 58.68 | .60 | – | trace. | .50 | .07 | .13 | trace. | 6.60 | 8.30 | – |
| 145 | 48.70 | – | 34.10 | 2.70 | .05 | .55 | trace. | .31 | .36 | .12 | 35.90 | 11.20 | – |
| 146 | 62.20 | – | 43.20 | 2.52 | .39 | .25 | 1.30 | 2.65 | .21 | .03 | 19.30 | 11.50 | – |
| 147 | 60.70 | – | 42.50 | 1.87 | .44 | .20 | 20 | .63 | not es | tim'td | 25.10 | 11.00 | – |

## IRON ORES—Continued.

### (*b*.) CARBONATES OF IRON

| Number in report. | Carbonate of iron. | Peroxide of iron. | Per centage of iron. | Alumina. | Carbonate of lime. | Carbonate of magnesia. | Carbonate of manganese. | Phosphoric acid and phosphate of lime. | Potash. | Soda. | Bituminous matter. | Silica, &c. | Water and loss. | Sulphur. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 7 | 65.96 | 7.19 | 36.90 | – | 5.90 | 6.03 | 1.57 | 2.64 | 0.23 | 0.06 | 1.03 | 8.70 | 0.67 | – |
| 14 | 14.26 | 16.77 | 18.55 | 5.83 | 35.15 | 6.54 | .84 | – | .29 | .08 | – | 19.17 | 1.05 | – |
| 24 | 12.42 | 14.07 | 15.86 | 2.91 | 18.48 | 1.49 | trace. | phos. l.<br>29.49 | .57 | .15 | 1.32 | 16.07 | 3.03 | –<br>– |
| 37 | 72.86 | 7.42 | 39.42 | 1.97 | 3.17 | 2.80 | 1.18 | .04 | .32 | .10 | – | 9.47 | .52 | .15 |
| 38 | 78.51 | 5.57 | 41.80 | 1.77 | 2.36 | 2.81 | 1.11 | .04 | .17 | .64 | - | 4.87 | 2.15 | – |
| 49 | 62.24 | 2.68 | 31.93 | 5.15 | 2.75 | 3.43 | 1.12 | .54 | .44 | .15 | not est | 18.17 | 3.33 | – |
| 50 | 56.58 | 4 86 | 30.70 | .25 | 2.95 | 2.17 | 1.68 | trace. | .44 | .38 | – | 30.10 | .59 | – |
| 60 | 46.40 | 8.28 | 28.20 | .35 | 32 15 | 3.26 | 1.24 | – | .23 | .17 | – | 2.57 | 5.35 | – |
| 61 | 23.56 | - | 11.35 | .48 | 67.33 | 4.82 | .41 | – | .23 | .10 | – | 1.99 | 1.08 | – |
| 74 | 41.98 | 44.66 | 43.65 | .55 | 4.35 | 1.84 | .86 | – | .27 | .67 | – | 5.15 | – | – |
| 75 | 70.39 | 13.14 | 43.20 | .37 | 4.75 | 4.68 | 1.46 | .18 | .19 | .05 | – | 2.45 | 2.34 | – |
| 97 | 79.72 | 4.52 | 41.26 | .08 | .97 | 3.08 | 1.23 | .34 | .24 | .18 | – | 9.64 | – | – |
| 100 | 60.36 | 2.33 | 30.46 | 2.65 | 3.35 | 3.58 | 1 43 | – | .47 | .05 | – | 24.67 | 1.09 | – |
| 118 | 70.60 | 5.42 | 37.53 | 1.55 | 2.15 | 4.91 | 1.25 | – | .25 | .09 | – | 13.37 | .41 | – |
| 120 | 65.93 | 8.63 | 37.55 | 2.27 | 1.97 | 3.34 | 5.03 | – | .07 | .18 | – | 13.17 | – | – |
| 121 | 42.68 | 17.02 | 32.37 | 2.05 | 1 68 | 1.52 | .71 | – | .27 | .30 | 11.10 | 20.66 | 2.01 | – |
| 122 | 17.42 | 24.80 | 25.68 | 2.79 | 32.85 | 6.36 | 1.81 | .60 | .11 | .17 | – | 10.47 | 2.62 | – |
| 134 | 17.84 | 25.08 | 25.30 | 1.00 | 5.97 | 7.30 | 1.20 | .36 | .20 | .09 | 2.50 | 34.65 | 3.81 | – |
| 148 | 64.87 | 4.39 | 34.18 | .67 | 3.56 | 4.26 | 1.09 | phos. l.<br>2.10 | .23 | .28 | 1.40 | 16.25 | .90 | –<br>– |
| 149 | 62.42 | 3.38 | 32.52 | .95 | 3.65 | 7.41 | 2.49 | .10 | .23 | .12 | 2.41 | 15.27 | 1.57 | – |
| 150 | 64.90 | 7.41 | 36.54 | .60 | 3.25 | 6.57 | 1.18 | .35 | .17 | .52 | 7.87 | 7.07 | .11 | – |
| 151 | 74.46 | 1.15 | 36.80 | .70 | 2 45 | 4.70 | 1.03 | .38 | notes | ti'ed. | 7.90 | 5.95 | 1.28 | – |
| 152 | 54.32 | 6.75 | 31.17 | .50 | 3.87 | 2.97 | 2.68 | .53 | .08 | – | 4.40 | 21.95 | 1.91 | – |
| 153 | 62.59 | 14.79 | 40.26 | 1.87 | 2.65 | 4.69 | 1.42 | trace. | .23 | .12 | not est | 8.19 | 3.41 | – |
| a. | 86.10 | .23 | 41.42 | .63 | 5.41 | 1.77 | - | – | – | – | 3.03 | 1.40 | 1.41 | – |
| b. | 85.44 | .23 | 41. | .63 | 5.94 | 3.77 | – | – | – | – | 3.03 | 1.40 | – | – |

Those which contain a notable proportion of bituminous matters are such as have received the name of Black Band Iron Ores, in Scotland, England and Wales.

For the purposes of comparison I have added to the table two analyses of one of the best of the European Black Band Ores, viz:

a. *Called "Mushet's Black Band," from its discoverer; from near Airdrie; analyzed by Dr. Colquohoun.*

b. *Same ore analyzed by Dr. Thompson.*

In different specimens of this variety of ore, as analyzed by Dr. Colquohoun, *bituminous matters* were found in proportions from 1.86 to 17.38 per cent.

| | |
|---|---|
| Alumina, from - - - - - - - - - | 1. to 5. per cent. |
| Silica, from - - - - - - - - - | 1.4 to 19.9 per cent. |
| Iron, from - - - - - - - - - | 25. to 40. per cent. |

Results which agree very well with those above shown in relation to the Kentucky ores.

## II. COALS, &c.

| Number in the report. | Specific gravity. | Per centage of moisture. | Volatile combustible matters. | Carbon in the coke. | Ashes. | Total volatile matters. | Coke. | Per centage of sulphur. | |
|---|---|---|---|---|---|---|---|---|---|
| 3 | 1 219 | 13.20 | 37.40 | 38.10 | 11.30 | 50 60 | 49.40 | not est. | Lignite |
| 6 | 1.321 | not est'md. | 38.00 | 53 90 | 8.10 | 38.00 | 62.00 | 0.085 | |
| 8 | 1.291 | 7.20 | 31.40 | 56.90 | 4.50 | 38.60 | 61.40 | .290 | |
| 9 | 1.247 | 4.00 | 34.70 | 60.70 | .60 | 38.70 | 61.30 | .268 | |
| 15 | 1.313 | 5.40 | 35.60 | 55.00 | 4.00 | 41.00 | 59.00 | .710 | |
| 16 | 1.443 | 4.00 | 33.50 | 42.70 | 19.80 | 37.50 | 62.50 | 7.905 | |
| 17 | 1.312 | 5.00 | 40.80 | 49.50 | 4.70 | 45.80 | 54.20 | 2.410 | |
| 18 | 1.307 | 2.80 | 41.10 | 48.90 | 7.20 | 43.90 | 56.10 | 2.160 | |
| 19 | 1.278 | 4.00 | 37.70 | 53.30 | 5.00 | 41.70 | 58.30 | 1.363 | |
| 25 | 1.316 | 2.00 | 35.00 | 55.40 | 7.60 | 37.00 | 63.00 | 1.040 | |
| 43 | 1.287 | 6.00 | 34.20 | 56.20 | 3.60 | 40.20 | 59.80 | 1.694 | |
| 90 | 1.320 | 3.90 | 37.30 | 50.20 | 8.60 | 41.20 | 58.80 | 1.448 | |
| 91 | 1.393 | 5.20 | 30.30 | 55.30 | 9.20 | 35.50 | 64.50 | 0.433 | |
| 101 | 1.288 | 3.40 | 34.90 | 57.90 | 3.80 | 38.30 | 61.70 | .734 | |
| 102 | 1.301 | 5.00 | 35.70 | 51.00 | 8.30 | 40.70 | 59.30 | 1.818 | |
| 123 | 1.213 | 4.20 | 35.80 | 57.80 | 2.20 | 40.00 | 60.00 | .268 | |
| 135 | 1.288 | 7.20 | 34.20 | 56.30 | 2.30 | 41.40 | 58.60 | 1.060 | |
| 136 | 1.272 | 4.40 | 41.10 | 51.10 | 3.40 | 45.50 | 54.50 | 1.560 | |
| 137 | 1.297 | 5.10 | 35.20 | 53.50 | 6.20 | 40.30 | 59.70 | 1.122 | |
| 156 | 1.221 | 3.10 | 45.30 | 48 50 | 3.10 | 48.40 | 51.60 | 1.350 | |
| 157 | 1.260 | 2.80 | 37.60 | 56.10 | 3.50 | 40.40 | 59.60 | .654 | |
| 158 | 1.348 | 8.70 | 24.60 | 59.20 | 7.50 | 33.30 | 66.70 | .550 | |
| 159 | 1.295 | 3.40 | 33.40 | 58.50 | 4.70 | 36 80 | 63 20 | .337 | |
| 160 | 1.211 | 1.10 | 48.90 | 47.00 | 3.00 | 50.00 | 50.00 | .241 | |
| 166 | not ascer | tained. | 40.70 | 52.30 | 7.00 | 40.70 | 59.30 | .880 | |
| 169 | 1.291 | 2.00 | 29.70 | 65.30 | 3.00 | 31.70 | 68.30 | .055 | |

## III. IRON FURNACE SLAGS.

| Number in the report. | Silica. | Lime. | Magnesia. | Alumina. | Protoxide of iron. | Protoxide of manganese. | Potash. | Soda. | Oxygen in the silica. | Oxygen in the bases. | Proportion of the O. in the bases, to the O. in the silica. | Furnace. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 40 | 55.00 | 27.10 | 1.95 | 12.30 | 1.57 | 0.27 | 1.73 | 0.08 | 28.55 | 14.95 | 1:1.91 | Pennsylvania. |
| 41 | 60.64 | 14.65 | 2.55 | 13.30 | 4.62 | .88 | 2.55 | .81 | 31.85 | 13.13 | 1:2.42 | Pennsylvania. |
| 47 | 56.90 | 13.20 | 3.46 | 20.50 | 2.43 | .51 | 3.16 | .36 | 29.55 | 16.00 | 1:1.85 | Buena Vista. |
| 52 | 52.20 | 17.25 | 3.25 | 23.30 | .16 | .27 | 2.20 | .91 | 27.10 | 16.00 | 1:1.69 | Bellefonte. |
| 64 | 56.10 | 24.18 | 1.40 | 13.90 | 2.07 | .55 | 2.16 | .39 | 29.13 | 14.95 | 1:1.96 | Buffalo. |
| 65 | 55.90 | 25.42 | 1.30 | 13.40 | 1.01 | .83 | 1.27 | .63 | 29.02 | 14.89 | 1:1.96 | Buffalo. |
| 66 | 57.90 | 17.56 | 2.30 | 13.97 | 6.03 | 1.02 | 1.04 | .18 | 30.06 | 14.86 | 1:2.01 | Buffalo. |
| 78 | 55.54 | 19.92 | 2.69 | 16.54 | 2.10 | .69 | 2.30 | .14 | 28.84 | 15.49 | 1:1.84 | Greenup. |
| 85 | 56.70 | 24.24 | 4.41 | 11.84 | 1.02 | .53 | 1.37 | .13 | 29.44 | 14.63 | 1:2.01 | Raccoon. |
| 86 | 61.80 | 18.34 | 2.40 | 13.00 | 2.97 | .31 | 1.08 | .15 | 32.11 | 13.19 | 1:2.43 | Raccoon. |
| 98 | 50.94 | 23.77 | 3.19 | 15.50 | 2.61 | 1.58 | 2.24 | .77 | 26.45 | 15.80 | 1:1.67 | Amanda. |
| 110 | 56.28 | 19.70 | 6.13 | 13.90 | 1.56 | 1.02 | 1.26 | – | 29.22 | 15.30 | 1:1.91 | N. Hampshire. |
| 111 | 56.34 | 19.58 | 6.59 | 14.30 | 1.36 | .87 | 1.00 | .22 | 29.25 | 15.61 | 1:1.87 | N. Hampshire. |
| 112 | 56.74 | 16.66 | 5.20 | 15.10 | 2.17 | 2.92 | 1.66 | .36 | 29.46 | 15.38 | 1.1.91 | N. Hampshire. |

## IV. PIG-IRON.

| Number in the report. | Specific gravity. | Iron. | Graphite. | Combined carbon. | Manganese. | Silicon. | Slag. | Aluminium. | Magnesium. | Potasisum. | Sodium. | Phosphorus. | Sulphur. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 42 | 6.770 | 92.08 | 3.03 | 0.36 | trace. | 2.91 | 0.16 | 0.07 | 0.24 | 0.12 | – | trace. | trace. |
| 48 | 6.903 | 91.88 | 1.65 | 3.15 | 0.35 | 3.27 | .30 | .07 | trace. | – | – | " | " |
| 53 | 6.915 | 94.54 | 2.25 | 1.08 | .35 | 1.26 | .18 | .08 | .17 | .21 | 0.03 | " | " |
| 67 | 7.086 | 93.12 | 3.10 | .65 | .18 | 1.06 | .14 | .03 | trace. | .15 | – | 0.70 | " |
| 68 | 7.322 | 94.70 | 2.20 | .75 | trace. | .60 | .26 | .05 | .02 | .14 | – | .48 | " |
| 79 | 6.877 | 91.21 | 3.13 | – | .48 | 3.57 | .22 | .30 | .18 | .05 | – | .67 | 0.05 |
| 87 | 6.898 | 90.18 | 2.80 | 1.00 | .59 | 5.13 | .93 | .08 | .07 | .05 | – | .37 | .01 |
| 88 | 6.798 | 91.85 | 2.40 | .73 | .18 | 3.55 | .51 | .09 | .08 | .06 | – | .34 | .04 |
| 89 | 6.867 | 88.57 | 2.25 | 2.00 | .63 | 6.88 | .47 | .15 | .15 | .03 | – | .44 | trace. |
| 99 | 7.433 | 94.89 | 3.00 | – | trace. | 1.55 | .11 | trace. | .09 | .05 | – | .79 | .20 |
| 113 | 6.843 | 93.12 | 2,83 | – | .34 | 1.23 | .13 | .52 | .06 | .33 | .21 | 1.30 | trace. |
| 114 | 7.241 | 93.19 | 3.13 | – | .20 | 1.28 | .18 | .44 | .06 | .19 | .09 | 1.40 | " |

## V. LIMESTONES.

| Number in report. | Specific gravity. | Carbonate of lime. | Carbonate of magnesia. | Carbonate of iron. | Carbonate of manganese. | Oxide of iron. | Phosphate of lime. | Bituminous matters. | Silica, &c. | Potash. | Soda. | Alumina, &c. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 21 | - | 52.20 | 37.95 | - | - | - | - | - | 6.38 | 0.28 | - | 2.27 |
| 22 | 2.786 | 65.69 | 1.57 | 8.00 | 0.34 | - | - | - | 11.37 | - | - | 13.23 |
| 39 | 2.776 | 95.25 | 2.74 | - | - | - | - | - | .57 | .09 | 0.08 | 1.27 |
| 51 | 2.687 | 97.17 | 1.39 | - | - | - | - | - | .55 | .11 | .09 | 1.17 |
| 62 | 2.669 | 81.55 | 2.44 | - | - | - | - | - | 15.56 | .09 | .02 | .35 |
| 63 | 2.688 | 87.97 | 2.72 | - | - | - | - | - | 7.15 | .20 | .58 | 1.85 |
| 76 | 2.803 | 71.45 | 3.73 | 13.19 | .51 | 1.56 | - | - | 7.33 | .19 | .10 | .47 |
| 77 | 2.977 | 91.50 | 2.53 | - | - | - | - | - | 3.97 | .13 | .10 | 1.15 |
| 84 | 2.687 | 61.95 | 2.35 | - | - | - | - | - | 30.17 | .25 | .24 | 4.95 |
| 108 | - | 53.85 | 22.10 | 7.41 | .86 | 4.41 | - | - | 7.97 | .21 | .19 | .37 |
| 109 | 2.708 | 97.85 | 1.30 | - | - | - | - | - | 1.27 | .15 | .50 | .55 |
| 132 | 2.560 | 39.90 | 20.50 | 11.71 | 1.02 | 2.22 | 5.23 | 6.05 | 12.41 | .17 | .09 | .60 |
| 133 | 2.613 | 40.09 | 22.17 | 7.32 | .28 | 3.53 | 2.24 | 7.25 | 16.60 | .21 | .14 | .17 |
| 154 | 2.520 | 85.00 | 1.15 | - | - | - | .63 | 3.14 | 7.95 | .38 | - | 1.57 |
| 164 | 2.704 | 96.03 | .74 | 1.09 | - | - | 1.19 | - | .66 | - | - | .16 |

REMARKS. No. 21 was sent as a *hydraulic limestone*. It contains much less than the quantity of silica and alumina usually present in good water limes. If it is found by experience to form a good water cement, its *hydraulic* character must be mainly due to the magnesia which it contains in large quantity.

No. 22, which was supposed to be an *iron-ore*, deserves trial as a water lime.

Nos 132, 133, and 14, resemble very much the Black Band iron-ores; but the small proportion of iron which they contain renders them of no value in this relation, especially as they generally contain injurious quantities of phosphate of lime, which will prevent their use as fluxes for the richer ores.

## VI. CLAYS.

| Number in the report. | Silica. | Alumina. | Oxide of iron. | Lime. | Magnesia. | Potash. | Soda. | Water. | Locality. |
|---|---|---|---|---|---|---|---|---|---|
| 4 | 71.94 | 20.70 | trace. | 0.37 | 0.35 | 0.63 | - | 6.20 | Ballard co., Ky. |
| 124 | 65.74 | 26.10 | trace. | .72 | .73 | .56 | 0.14 | 6.01 | Greenup co , Ky. |
| 125 | 51.74 | 33.90 | trace. | .62 | .73 | .88 | .31 | 11.82 | Greenup co., Ky. |
| 167 | 73.00 | 17.60 | 3.00 | .60 | - | .10 | - | 5.70 | Union co., Ky. |
| a | 61.01 | 23.60 | 5.66 | .82 | .51 | .56 | 1.41 | 6.15 | England. |
| b | 63.30 | 23.30 | 1.80 | not | estimat | ed. | not est. | 10.30 | England. |
| c | 72.96 | 24.78 | - | 1.04 | trace. | alkalies, 1.22 | | - | Germany. |
| d | 71.04 | 22.46 | - | 3.82 | - | alkalies, 2.68 | | - | England. |

**Remarks.** For comparison, the composition of four foreign clays is given above.

a. From the white bed, plastic clay formation, used in pottery, near Farnham. Analyzed by Mr. Way.

b. Best Stourbridge fire-clay.

c. Berlin porcelain ware, (burnt?)

d. Superior porcelain clay.

## VII. SOILS.

| Number in report. | Dissolved by water containing carbonic acid from 1000 gr. | Moisture. | Organic matters. | Carbonate of lime. | Carbonate of magnesia. | Carbonate and oxide of manganese. | Phosphoric acid and phosphates. | Potash. | Soda. | Alumina and oxide of iron. | Silica, &c. | Sulphate of lime. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1.530 | 1.84 | 3.04 | 0.034 | 0.461 | 0.411 | trace. | 0.108 | 0.037 | 3.93 | 92.01 | - |
| 2 | 1.943 | 2.44 | 4.12 | .134 | .280 | .081 | trace. | .139 | .063 | 4.85 | 89.65 | - |
| 10 | 1.884 | 1.86 | 3.46 | .097 | .305 | .025 | trace. | .204 | .074 | 5.03 | 90.59 | - |
| 20 | 3.822 | 2.60 | 5.68 | .220 | .280 | .415 | trace. | .154 | .061 | 5.47 | 87.43 | 0.19 |
| 27 | - | 4.44 | 8.00 | .494 | .420 | - | phos l<br>.26 | .205 | .062 | 4.181 6.170 | 79.91 | - |
| 28 | - | 4 58 | 5.98 | .530 | .527 | .204 | .45 | .139 | .031 | 4.528 7.190 | 80.43 | - |
| 29 | 1.115 | 1.72 | 1.72 | 1.540 | .517 | .036 | trace. | .108 | .052 | 4.47 | 92.35 | - |
| 30 | 1.275 | 3.80 | 2.60 | .393 | .503 | - | trace. | .170 | .082 | 9.51 | 87.03 | - |
| 126 | 7.043 | 2.04 | 5.08 | 1.254 | .447 | - | trace. | .085 | .034 | 3.49 | 89.67 | - |
| 127 | - | 1.60 | - | .900 | 4.350 | - | trace. | .070 | .020 | 3.60 | 90.99 | - |
| 128 | 0.270 | 2.30 | 2.00 | 1.150 | .160 | .170 | .19 | .170 | .020 | 6.00 | 90.57 | - |
| 129 | - | 5.00 | 4.80 | 1.250 | .260 | trace. | trace. | .520 | .300 | 8.65 | 84.04 | - |
| 138 | - | 1.88 | 3.88 | .060 | .210 | trace. | trace. | .100 | .060 | 6.15 | 89.19 | - |
| 140 | 0.453 | 3.76 | 3.24 | 0.370 | .405 | .400 | trace. | .108 | .200 | 9.77 | 85.83 | - |
| 141 | 1.390 | 2.30 | 3.50 | .196 | .118 | .119 | phos l<br>.045 | .181 | .171 | 5.16 | 90.06 | - |
| 155 | 7.780 | 2.85 | 5.80 | 1.070 | .540 | .310 | .68 | .190 | .030 | 5.05 | 86.64 | - |
| 161 | 2.946 | 2.80 | 5.10 | 1.940 | .307 | .235 | trace. | .131 | .070 | 6.51 | 87.47 | - |
| 162 | - | 2.00 | 4.10 | 1.420 | .240 | - | trace. | .110 | .030 | 4.10 | 88.30 | - |
| 163 | 1.693 | 2.80 | 4.18 | .194 | .475 | .114 | trace. | .178 | .095 | 6.83 | 87.83 | .04 |
| 165 | 1.043 | 1.74 | 3.28 | .034 | .195 | .195 | trace. | .096 | .022 | 3.62 | 92.31 | - |
| 168 | 1.042 | 2.18 | 2.90 | .094 | .350 | .054 | phos l<br>.22 | .150 | .043 | 5.129 | 90.99 | - |

## SUPPLEMENT TO FAYETTE COUNTY, KENTUCKY.

### MINERAL WATERS.

In the summer, 1852, Mr. John S. Wilson, boring for water in the cellar of his store, on Cheapside, Lexington, (opposite the court-house,) obtained a pretty strong saline *chalybeate water*—a kind of mineral water which is somewhat rare in our blue limestone (lower silurian,) formation.

This water first appeared forty feet below the level of the street, after boring through twenty-six and a half feet of solid limestone containing hard masses of pyrites.

The water effervesces slightly; has a marked saline and chalybeate taste, and speedily deposits a red ochreous sediment when allowed to stand exposed to the atmosphere. It has been much employed, since its discovery, as a remedial agent. Its strength is found to vary at different times—being often greater just before a rain. It appears to have become slightly weaker, but has not materially altered since it was first obtained.

An average proportion of its saline contents was obtained by slowly evaporating, in a beaker glass, on the water bath, two hundred and forty ounces Troy, supplied to the glass as the water evaporated during the course of nine months.

The proportion of *free carbonic acid*, as ascertained by a separate process, in which it was precipitated by ammoniated chloride of barium, is as follows:

| | in 20 ℔s Troy, | in 1 ℔ Troy. |
|---|---|---|
| Free carbonic acid, - - - - | 39.0428 grains, | 1.9521 |
| | 82.6000 cubic inches, | 4.1300 |

Composition of saline contents—

| | In 20 ℔s Troy. | In 1 ℔ Troy. | |
|---|---|---|---|
| Carbonate of iron, - - - - | 6.3003 | 0.3150 | In the insoluble portion, on evaporation. |
| Carbonate of lime, - - - - | 36.5871 | 1.8293 | |
| Carbonate of magnesia, - - - - | 2.5610 | .1280 | |
| Sulphate of lime, - - - - - | 4.9109 | .2455 | |
| Silica, - - - - - - - | 1.3748 | .0687 | |

| | | |
|---|---|---|
| Chloride of sodium, - - - | 133.2590 | 6.6620 |
| Chloride of potassium, - - - | 5.6604 | .2880 |
| Chloride of calcium, - - - | 83.7314 | 4.1865 |
| Chloride of magnesium, - - | 44.1349 | 2.2067 |
| Sulphate of magnesia, - - - | 4.2359 | .2117 |
| Bromide of magnesium, - - | 1.9801 | .0990 |
| Silica, - - - - - - - | 2.3200 | .1160 |
| | 327.0558 | 16.3525 |

The mineral waters usually found in this formation contain sulphuretted hydrogen, with chloride of sodium, &c., &c., as exemplified in the composition of the celebrated Blue Lick water.

The waters of almost every deep bored well in this neighborhood exhibit more or less evidences of the presence of the saline and gaseous ingredients which characterize the Blue Lick water; some in so small amount as to have a mere trace of sulphuretted hydrogen, others so strongly as to entitle them to be classed as mineral waters. In some the common salt predominates, and sulphuretted hydrogen is almost entirely absent; all bearing evidence to the sub-marine origin of our limestone strata. The full examination of the various mineral waters of this and the other formations must be reserved for future investigations.

# APPENDIX TO THE CHEMICAL REPORT OF THE GEOLOGICAL SURVEY.

Most of the time allotted to this part of the survey having been devoted to the laboratory work, less in space is given to theoretical views and general applications than perhaps would have been satisfactory to some of the readers of the report. The writer was, however, impressed with the importance of the fact that the careful ascertainment of truth should be the basis of all reasoning, and that, especially in the study of natural objects and processes, nothing can supercede, in the commencement, the patient labor of observation and experiment; that, moreover, when the composition of our Kentucky ores, soils, and minerals in general is once accurately established, their applications to our wants and uses would be obvious to all well informed persons. He has therefore consumed the time mainly in the analyses, and made up his report principally of their results.

It would have been easy to have filled many pages of the report with *general considerations, applications*, or *theoretical views* in regard to the soils and minerals of our State, in relation to the cultivation of the soil, the manufacture of iron, or to other manufactures in which they are employed; to have made the report an elementary work on agriculture and the mechanical arts; but there are many good works, easily accessible to persons interested in these pursuits, in which these matters are fully developed; and the writer has thought it to be his first duty, at this stage of the business, to endeavor to make out the composition of as many of the soils and minerals of Kentucky as would be possible in the time which he had at his disposal, leaving for the future the general considerations and applications which might naturally present themselves.

The study of the *science* of agriculture is becoming more and more important as the good lands of our country become gradually deteriorated by a thriftless husbandry, or as the poorer lands are brought into cultivation. Whilst the country is new, and the soil so rich that successive cropping for a number of years causes no very sensible diminution of its products, it cannot be expected that the farmer will care much or know much of those essential elements, resident in the soil, without which no plant can grow or mature its seed; but the time will inevitably come when this subject will be forced upon the attention of the agriculturist and the political economist, and the study of the *science* of the cultivation of the soil will become a first necessity.

It is the part of a wise and provident man, or nation, to look at and provide for future contingencies, and it is not too soon now to begin the work of the ascertainment and diffusion of this kind of knowledge. Already some of our richest soil, in the blue-grass region, shows, by chemical analysis, evident signs of partial loss of the indispensable ingredients of its fertility; as may be seen by comparing the analysis of No. 27 with that of No. 28; the one virgin blue limestone soil from Fayette county, Kentucky; the other, soil from the same tract, taken from a spot in close proximity, which has been for many years in cultivation, (see also page 100 of Dr. Owen's general report;) and there can be no doubt that similar comparative examinations, of the uncultivated and long cultivated soils from other districts, would show precisely analagous results.

The idea that the soil is inexhaustible—a bank on which we may draw forever without precaution—is held at present by very few, theoretically, although *practically* the great majority of our farmers seem to entertain it, and act upon it without scruple. The positive facts, which have been ascertained by chemical analysis, in relation to the elements of plants and of organic beings generally, are gradually becoming known to the masses, and by the improvement of the common education of the people, we may hope that this knowledge, so important to agriculture and the arts in general, will be more widely diffused.

It is demonstrated, by general experience in the laboratory, that no vegetable, the most minute, can grow, no microscopic vegetable cell, in short, can be formed without the assistance of certain mineral substances, always to be found in fertile soils; and that whilst the greatest proportion of the weight of vegetable and other organic bodies, composed of carbon, hydrogen, nitrogen and oxygen, may be derived from the gases of the atmosphere and from water, the *fixed materials*, always found in their ashes, drawn from the soil by the living plant, are equally essential to vegetable growth. In the absence of these, whatever may be the abundance of the atmospheric elements, vegetable developement would be impossible; even the absence of one or more of them would prove an insuperable obstacle to growth.

As the atmospheric elements are everywhere abundant, these *fixed elements*, existing in the soil and in the surface water, are more especially worthy of the attention of agriculturists in all parts of the world. It was the removal of these, or of some of them, by successive exhausting crops of tobacco, corn, &c., which caused the reduction of much of the soil of Virginia from a state of high fertility to one of almost hopeless sterility; as, on another continent, the constant exportation of grain has rendered worthless countries which formerly were the granaries of Europe; a spendthrift system which, if long continued, will, in the course of time, bring even the rich prairies of the West to the condition of sun-burnt deserts.

In order justly to appreciate the value of the mineral ingredients of vegetables, the reader, having acquired some knowledge of elementary chemistry, may consult some of the recent valuable publications on the chemistry of agriculture; none, perhaps, would be more satisfactory than the "*Lectures on the Applications of Chemistry and Geology to Agriculture.* By Jas. F. Johnston;" re-published in this country by Wiley and Putnam; and there are other good works on these subjects, of more recent publication, easily accessible.

The examination, by chemical analysis, of the ashes of plants in which these mineral ingredients are always found in their natural proportions, enables us to appreciate fully their value in the economy of organic nature. In no plant or part of vegetable tissue are they absent. Usually all present in every plant, they vary in their relative proportions in different vegetables, and even in different parts of the same vegetable—some plants requiring for their healthy growth more potash, some more soda, lime, oxide of iron, silica, or phosphates than others. A soil which contains them all in sufficient abundance is a fertile soil; and one from which they are entirely absent is hopelessly sterile until they are supplied.

These important elements of vegetable nourishment are potash, soda, lime, magnesia, oxide of iron, oxide of manganese, phosphorus or phosphoric acid, sulphur or sulphuric acid, chlorine, silica, and a few others found in minuter proportion. These exist in various states of combination in the fertile soil, and in relatively small proportion, except the silica, in particular, which forms the greatest weight of all soils, but in the insoluble state of sand, in various degrees of fineness. They are all dissolved, in notable quantity, by the water which falls from the atmosphere, principally by the aid of the carbonic acid which it always contains, and partly by the organic acids resulting from the decomposition of animal and vegetable substances in the soil. The operation employed in the analyses of the soils, given in the present report, by digesting them in water containing carbonic acid, always showed the solution of a considerable quantity of these nutritious mineral ingredients, and exemplified the mode in which these substances, generally little soluble in pure water, are naturally dissolved and made available for vegetable nourishment.

To give an idea of the quantity of these substances removed from the land in the usual course of cropping, the following table is appended. It has been collated from the second volume of *Dr. Emmons' Agriculture of New York,* prepared and published at the expense of that State, as a part of the great work, "on the *Natural History of New York.*"

| Inorganic matter removed from the soil in the following vegetable products. | Potash. | Soda. | Lime. | Carbonate of lime. | Magnesia. | Phosphates of lime and magnesia. | Phosphates of potash and soda. | Sulphuric acid. | Chlorine. | Chloride of sodium. | Silica. | Total. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ℔ | ℔ | ℔ | ℔ | ℔ | ℔ | ℔ | ℔ | ℔ | ℔ | ℔ | ℔ |
| One ton of potatoes, (tubers,) - - - - - - - | 8.40 | 3.00 | 1.00 | - | 1.61 | 3.57 | - | 1.70 | 0.21 | - | 0.51 | 20.00 |
| One ton of parsnips, (roots,) - - - - - - - | 32.59 | 12.04 | - | 0.83 | .60 | 33.56 | not | giv- | en. | - | 11.90 | 91.52 |
| One ton of timothy hay, - - - - - - - | 18.46 | .61 | - | .12 | .30 | 10.15 | - | 2.48 | - | 1.49 | 26.40 | 60.01 |
| One ton of clover hay, - - - - - - - - | 32.15 | 18.40 | - | 38.39 | 4.87 | 25.54 | - | .62 | 2.29 | - | 1.05 | 123.30 |
| One ton of oat straw, - - - - - - - - | 98.16 | 5.92 | - | 11.87 | .73 | 14.55 | - | 9.41 | .95 | - | 21.91 | 163.49 |
| One ton of wheat straw, - - - - - - - - | 8.06 | 2.35 | - | 1.17 | .28 | 9.19 | - | 2.47 | .26 | - | 84.84 | 108.62 |
| Fifty bushels of oats, - - - - - - - - - | 16.07 | 4.89 | - | .06 | .07 | 25.00 | 8.75 | 1.81 | .02 | - | 28.15 | 84.82 |
| Twenty bushels of rye, - - - - - - - - - | 2.19 | 1.07 | .03 | - | .05 | 5.82 | .73 | .57 | - | .09 | .42 | 10.97 |
| An acre of summer wheat (the grain,) - - - - - | 3.84 | .87 | - | | .005 | 12.53 | 5.07 | .14 | - | - | .69 | 23.145 |
| An acre (white flint) indian corn, 14,700 plants, (the grain,) | 14.95 | 14.12 | .10 | - | 1.51 | 22.19 | - | 2.74 | .31 | - | 5.94 | 61.85 |
| An acre (white flint) indian corn, 14,700 plants, (the cob,) | 12.31 | 2.03 | .10 | - | .31 | 8.23 | - | .12 | .04 | - | 4.68 | 27.83 |

Collated from the 2d volume of Dr. Emmon's Agriculture of New York.

## TECHNICAL TERMS.

Complaints are sometimes made, by practical farmers, that the reports of agricultural chemists, and works on agricultural chemistry are too technical for their comprehensions. The use of technical or scientific terms is deprecated, even by some well educated persons, as tending to darken the subject. A little reflection, however, will enable them to see that they are just as indispensable as the different names used to designate different persons, and that instead of obscuring they render the language lucid and definite; and for this purpose, as well as to designate substances and properties which are not usually mentioned in *common parlance,* they are necessarily employed. In the present age of scientific advancement and application it should be part of every system of common education to give a knowledge of the general principles and ordinary terms of modern science, and especially those of natural science; and when our educational systems are better adapted to the progress of science and improvement, these terms will be no more difficult to the educated man than the names in the Heathen Mythology are to the classical scholar.

In the present report it is believed that no terms are used which are not defined in Webster's folio or octavo dictionary.

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## RE-EXAMINATION OF THE SOILS FOR PHOSPHORIC ACID.

The correct estimation of minute quantities of phosphoric acid in complex mixtures, especially when, as in soils, it is associated with lime, magnesia, oxide of iron, and alumina, is a matter of considerable difficulty. The various processes which have been hitherto proposed are generally either inaccurate or exceedingly tedious; hence perhaps the reason why, in soil analyses, the phosphates are not as frequently estimated as their very great importance to agriculture renders desirable.

Having procured some molybdate of ammonia, and repeated the process of Sonnenschein for the estimation of phosphoric acid by means of this re-agent, the writer was convinced that this is at once the easiest, most generally applicable, and most reliable, with certain precautions, of all the methods for the estimation of this acid. He has, therefore, while this report was going through the press, submitted all the soils described in it to a new examination by this process. The results are as follows:

*Per centage of Phosphoric Acid in the soils described in the preceding pages, each dried as there stated.*

| | | PER CENT. |
|---|---|---|
| No. 1. | Soil from southern part of Ballard county. Phosphoric acid, | —0.116 |
| No. 2. | Soil from north-west part of Ballard county. Phosphoric acid, | .155 |
| No. 10. | Soil from southern part of Butler county. Phosphoric acid, | .076 |
| No. 20. | Soil from southern part of Christian county. Phosphoric acid, | .129 |
| No. 27. | Soil from Fayette county. Virgin soil. Phosphoric acid, | .466 |
| No. 28. | Soil from Fayette county. Soil of old field. Phosphoric acid, | .379 |
| No. 29. | Soil from Hickman, Fulton county, (bluff.) Phosphoric acid | .102 |
| No. 30. | Soil from Hickman, Fulton county, (under the gravel bed.) Phosphoric acid, | .157 |
| No. 126. | Soil from Henderson county. Phosphoric acid, | .129 |
| No. 128. | Soil from Hickman county, white soil. Phosphoric acid, | .129 |
| No. 138. | Soil from Hopkins county, soil and sub-soil. Phosphoric acid | .089 |
| No. 140. | Soil from Livingston county. Phosphoric acid, | .064 |
| No. 141. | Soil from southern part of Logan county. Phosphoric acid, | .076 |
| No. 155. | Soil from northern part of Muhlenburg county. Phosphoric acid, | .090 |
| No. 161. | Soil from northern part of Simpson county. Phosphoric acid, | .129 |
| No. 162. | Soil from Todd county, red clay sub-soil. Phosphoric acid, | .062 |
| No. 163. | Soil from Todd county, soil and sub-soil. Phosphoric acid, | .156 |
| No. 165. | Soil from Trigg county, barren oak land. Phosphoric acid, | .063 |
| No. 168. | Soil from western part of Warren county. Phosphoric acid, | .076 |

The soils which have been analyzed since the preparation of the body of this report have all been submitted to this same process for the estimation of their phosphoric acid.

ROB. PETER.

# TOPOGRAPHICAL GEOLOGICAL REPORT

OF THAT PORTION OF

# KENTUCKY

INCLUDING

# UNION AND PART OF CRITTENDEN COUNTIES,

SURVEYED DURING THE YEARS 1854 AND 1855,

BY

## SIDNEY S. LYON,

TOPOGRAPHICAL ASSISTANT.

*To* Dr. David Dale Owen,
*Principal Geologist of Kentucky.*

Sir:—In compliance with your instructions, bearing date September, 1854, I herewith submit my report of the detailed Geological Survey, made by my corps, of Union and part of Crittenden counties, Kentucky, with the maps, profiles, &c.

SIDNEY S. LYON.

# TOPOGRAPHICAL REPORT.

Having received the appointment of assistant to the Geological Survey of Kentucky, approved June, 1854, and having qualified by the 8th of that month, it was not until the September following that I was ordered into active service, when having received instructions to take the field, I proceeded to make a reconnoisance of part of Union, Crittenden, and Livingston counties, mainly to ascertain the most effectual method of correcting the very imperfect and false plats of those counties, as they were exhibited on the best known and approved maps of Kentucky. An actual linear survey having been determined upon, it was proposed, if practicable, that a survey of the nature of the present coast survey made by the government of the United States should be adopted.

The features of the country were found, by examination, to be in many respects favorable to a survey of this character, there being a sufficient number of commanding ridges with many subordinate isolated knolls well situated for stations for a primary triangulation; but the expense necessary for the establishment of such stations, and especially the immense labor that would be required in removing the primative forest around and in the lines between stations, would involve the outlay of sums entirely beyond the control of this branch of the survey.

The rectilineal method of surveys was then considered. This method divides a territory into squares of one square mile each, by lines intersecting each other at right angles, supposed to be due north and south and east and west. Practically this method has been found to abound in errors, and requires corrections, both in course and quantity at the beginning of every township or square of thirty-six square miles. This method would require that there should be carefully surveyed, and marked eighty-four miles of line and a travel of at least as many additional miles, or one hundred and sixty-eight miles of travel for every thirty-six square miles, equal to four hundred and sixty-six miles of travel to every square mile of territory examined. This method was therefore rejected as too expensive for the limited means appropriated for this branch of the work.

It was therefore determined that a traverse survey should be adopted as the only method within the reach of this branch of the service by which approximate results could be obtained.

This method having been determined upon, and the mode and manner of carrying the same into execution being left to my discretion, I proceeded to organize my corps for field duties.

Owing to the unusual duties required it was found exceedingly difficult to procure the necessary assistants, and it was not until the 4th day of December, 1854, that the field work was commenced in form, the topographical corps consisting of Sidney S. Lyon, Walter A. Nicholson, sub-assistant, Wm. Carr, James M. Price, and H. C. Sherman, this corps being provided with a van for carrying the camp from point to point as the progress of the work required.

From the facts obtained during the reconnoissance it was deemed advisable that the survey should commence at some one of the best established points on the Ohio river near the margin of the Great Western coal field; Caseyville, in Union connty, was selected as the point at which the work should commence.

Owing to the very unsystematic manner in which the early land surveys of Kentucky were made, there are few or no well established geographical points in the State; the boundary of the State formed by the Ohio river, having been established approximately by the surveyors of the United States lands lying in Ohio, Indiana, and Illinois, has been copied from those surveys and applied to the maps compiled for Kentucky.

The lines of Green, Kentucky, Licking, Big Sandy, and probably some of the smaller rivers surveyed under the direction of the State Board of Internal Improvement of Kentucky, are perhaps also approximately correct, but I have no accurate information as to the character and extent of these surveys. Indeed I am not aware that any surveys at all reliable have even been officially published of Kentucky geography.

With the exceptions above alluded to there are probably no surveys in Kentucky that have had any further object in view, than giving boundaries to land, and the surveys for this purpose have not generally been returned for record in such form as to be of any practical utility in the construction of maps of the territory so surveyed.

On the 4th of December, the topographical corps took the field, starting at the shore of the Ohio river at low water mark, and extending the lines in various directions, making special note of such matters as were of topographical and geological interest met with on the lines, and when practicable observing angles from the lines to all inhabited houses. The lines were run with reference to the geological or topographical character of the country.

On the 21st of December it was deemed advisable to increase the force employed, and run lines of levels simultaneously with the compass lines. Mr. Sherman having fallen sick, was paid off, and Franklin Armstrong and John Cawthon were added to the corps, and compass and level put into active operation, and the work continued until the 21st day of January, 1855. The weather being now unfavorable, the corps were directed to report to you at head quarters, and were paid off and discharged for the season.

I then proceeded to make up the field work. The topographical corps again took the field on the 26th day of April, reduced, however, in force in consequence of our limited means, now consisting of myself and two chainmen.

With this force the work was continued until June 8th, 1855, when the assistants were paid off and discharged, after which the field work was continued until the 1st of July, when active field operations ceased.

In October the office work was resumed, and the entire field work laid down on a scale of 3.8 inches to the mile. This map has been reduced to a scale of $\frac{1}{50,000}$ or 1.2672 inches to the mile.

For convenience in referring to this map, as well as for a systematic division of the territory, it has been laid off into squares of one mile each, and the larger divisions into squares of thirty-six miles or townships. These townships are the result of the extension of the township lines from the neighboring States of Indiana and Illinois, eastwardly and southwardly, and have been marked eastwardly and westwardly from the meridian of Uniontown; and northwardly and southwardly from the township line, passing from Indiana into Union county, where it nearly intersects the mouth of Highland creek; the latter line, if reduced eastwardly into a *base* line, will run nearly centrally through the State. This mode of dividing the map will greatly aid the eye in judging of distances, and will facilitate all references made to it, and is probably the best division of the State that can be adopted.

It will be seen that the territory covered by the map embraces an area of about five hundred square miles, of the counties of Union and Crittenden.

## TOPOGRAPHY.

The principal and highest range of hills in Union county is known as the Bald Hill Range. It rises in Township 2 S., Range 2 W., and extends due four miles, to the flat lands known as the Scatters of Cypress.

This range again makes its appearance in section 11, T. 2 S., R. 1 W., extending eastwardly to that part of the range known as the Chalybeate Hills, having passed through sections 11, 12, 13, and 14, T. 2 S., R. 1 W., entering T. 2 S., R. 1 E., in section 18, passing through that section, and sections 17 and 16 of the same township; here the range inclines slightly to the south, passing into sections 21 and 22, which it crosses diagonally south-east and north-west into and through section 23, crossing the last section by the same course, forming what is known as the *Sulphur Spring* Hills. From this point the range branches, and throws off long spurs on the south; one spur encircles the head of Eagle (creek) fork of Cypress, and is connected by low undulating hills. On the south side of this creek, to the dividing ridges between Eagle and Wash creeks, another long spur is thrown off southwardly, which forms the dividing line between the waters of Dyson's and Ramsey's creeks; on the north, low spurs are thrown off, dividing the waters of Lost creek and the waters of Cypress, Lost creek and Big Mason, Big Mason and Casey's creek, Casey's and Anderson's creek, with a number of minor spurs dividing the smaller branches, near the head of Highland creek. Eagle, Dyson's, Anderson's and Casey's creeks have their sources in the Sulphur Spring hills. Lost creek rises on the north side of the same range near the Chalybeate Springs. From the Sulphur Spring hills the Bald hill range is broken into a number of nearly parallel ridges, which extend into Hopkins county by a course nearly east and west. The greatest elevation ascertained along this range being equal to 325 feet above low water of the Ohio river in 1854.

North of the Bald hill range there is an irregular range of hills rising in altitude in section 20, T. 1 S., R. 1 W., extending in a north-eastwardly direction through sections 21, 22, 23, and 13 of the same township, and into section 18, T. 1 S., R. 1 E.; here this range is separated by the valley of Lost creek, rising again in section 8, same township, the range is continued along the north side of Little Mason creek to and east of the Morganfield and Henderson road, on Highland creek, while the west end of this branch of the range runs from section 8 northwardly, and terminates in bold escarpments against the flat inundated river bottoms above Highland creek which meanders sluggishly at their base.

The "Anvil Rock" range of hills rise in section 10, T. 3 S., R. 2 W., where this range of hills attain their greatest height, (245 feet above high water,) running with a gradually decreasing elevation through sections 11, 11, 14, and 13, T. 3 S., R. 2 W., entering T. 3 S., R. 1 W., in section 18, which it crosses, and enters the rich flat lands at the head of Locust Lick creek, and is only indicated by symmetrical knolls of various sizes, sometimes rising sixty-five to seventy feet in height, having a base varying in area from five to seventy-five acres, terminating in a rounded irregular hill in section 21, same township; here it has a less elevation and passes through sections 22, 27, and 26, forming a sloping table, abrupt on the south, with a gradual inclination on the north, to Cypress creek. This range again appears on the east side of Cypress, where it occupies a greater base and is most favorably seen at "Poplar Ridge," and "Coal Hill," in sections 25 and 26, same township; continuing in the same course it extends through section 31, T. 3 S., R. 1 E.; sections 5, 9, 10 and 24, T. 4 S., R. 1 E; sections 19, 30, 29, and 32, T. 4 S., R. 2 E; passing into Hopkins county, the direction changes more to the east extending into section 33, and same township.

"*Bethel Hills*" form a bold and well defined range in sections 7 and 8 in T. 3 S., R. 1 W., extending eastwardly into sections 1 and 12, T. 3 S., R. 2 W., and is lost and obliterated by the Scatters of Cypress; it appears again in sections 27 and 21, T. 2 S., R. 2 W., where it attains an elevation of 255 feet.

In this township the masses forming the Anvil Rock, Bethel, and the Eagle creek, or Jerusalem school house range (?) are crowded together and form apparently a confused range of hills and ridges, which, however, are susceptible of separation.

The hills occupying section 15, N. E. corner of 24, S. W. of 14, and N. W. of 23, being formed by all the masses lying below the Anvil Rock range, and above the rocks of the millstone grit series, which form the southern slopes of Bald hill. There is also a well marked line of division between the masses forming the ranges of the Bethel hill and Jerusalem hill. This line enters section 24 on the east side, with the line of a nameless branch; then by a north-west course crosses section 24, and enters section 15; and down another nameless branch, a tributary of Cypress of the Ohio. Between the sources of these two streams the *hills* are reduced from two hundred and fifty-five feet to about thirty-five feet above high water, or seventy-five feet above low water of the Ohio river.

Eastwardly the Bethel hill range rises again in section 9, T. 3 S., R. 14, and extends in a course due east across the township, when it is lost in the low rich flats of the Pond fork of Crab Orchard creek; appearing again in section 30, T. 3 S., R. 1 E., when it attains an elevation to the same range in section 7, T. 3 S., R. 1 W., when it was found to be 247.84 feet above low water at Caseyville, 1854. Further eastwardly this range has not been satisfactorily determined.

On the Ohio river, at Caseyville, the millstone grist rises in a bold range of hills, having a course nearly north and south, capped in many places by the masses of the lowest workable coal beds. This range extends to Trade-water river, making a bold rocky bluff on either side of the gap through which this stream finds an outlet into the Ohio. On the south side of Trade-water these bold rough masses extend in a course varying to the east of south. In section 20, T. 4 S., R. 1 E., they attain an elevation of about four hundred feet. At this point the line of these hills changes its direction and runs parallel to the general direction of Trade-water, running boldly up to that stream in section 16, T. 5 S., R. 1 E., defining with a strongly marked outline the limit of the productive coal measures.

This range of hills having no general name, may be appropriately denominated the conglomerate range.

A very marked peculiarity of this district is that all of the ranges of hills enumerated are severed by low lands, crossing these lines nearly at right angles with their direction. The subject will be noticed more in detail in the course of this report.

### DRAINAGE.

The drainage of this district necessarily depends on the configuration of the hills and dividing ridges, therefore, the lines of the principal streams conform nearly to east and west courses, except when the dividing ridges have been severed by denudation, or when they have sunk so far below the general elevation of the range to which they belong that the water courses find their beds above the rocks which along other parts of the ranges form their summits.

*Trade-water.*—This river enters the Ohio two and a half miles below Caseyville, in T. 4 S., R. 2 W. The general direction of this stream is from south-east to north-west, but it is remarkably crooked; and the current very gentle, being in fact a succession of pools, separated by gentle ripples, having a fall of less than four inches to the mile.

*Cypress Creek.*—This creek takes its rise in the "Bald Hill" range, where it is known as Eagle creek, and for some distance of its course receives most of its tributaries from the north side, all rising in the Bald hill range. It runs southwardly about two miles over the upturned edges of the coal measures, which abut conformably on the western slopes of this range, the main body of the hills being formed by the tilted rocks of the millstone grit and sub-carboniferous limestone, which are protruded through the masses of the coal measures, and may be found in many places in this range dipping south, south-east, and south-west, at angles varying from 71° to 18°, the angle of dip gradually decreasing to the south of this range as the elevation becomes less. The upper part of this stream having had a course to the north-west for several miles, with a well formed bed in section 15, T. 2 S., R. 1 W., reaches a flat known as the Scatters of Cypress, where for several miles no regular defined bed can be traced; the waters of the stream, speading far and wide, make a great curve to the west, and pass around and through the gaps in the Eagle creek or Jerusalem School House hills and the Bethel hill range.

After being thus deflected they flow in a line nearly parallel to the latter range, along its south side, in a south-east course, until it reaches section 26, T. 3 S., R. 1 W., when it is turned to the south-west by a fallen southwardly or towards the line of the fault, and as far as ascertained the uppermost beds observed are not lower than the 6th coal of the upper series; all the coals of the lower series will probably be found too deep seated for profitable workings north of this range.

The coals numbered 6, 7, and 8 of the upper series will probably be the only coals that may be profitably worked in Union county, north of the Bald hill range.

South of the Bald hill range there is no difficulty of reaching each of the eight beds of both series at their out-crop. On the west side of Cypress of the Ohio this out-crop has been duplicated, the lower beds having been brought again to the surface by the Bald hill uplift.

North of the Bald hill range, in the line of most favorable out-croppings of the upper series, these coals have been reached in several places; at one hundred and fifty feet on Highland creek three of these beds have been penetrated by three several borings made by Dr. John T. Berry; two of the upper of these beds have been entered by boring on the farm of Mr. Wilson in section 27, T. 1 S., R. 1 W., at a depth of one hundred feet. The sixth coal of the upper series has been entered in natural out-crop in several places on sections 5 and 8, T. 2 S., R. 1 W., where it is known as the "Blue Coal."

The broken and disturbed beds of the upper measures have also been entered and worked, to a limited extent, near the Sulphur Springs on Casey's creek, in section 25, T. 2 S., R. 1 E.; another bed has been opened in the same section. The first of these beds is four feet thick, and dips south-eastwardly at an angle of 45°, while the second is but twenty-eight inches, dipping in the same direction at an angle of 15°. A coal four feet in thickness, standing vertically, has been worked to the depth of six feet, when it gave out, being a fragment of the beds disturbed and broken by the Bald hill dislocation or uplift. This bed lies in section 28, T. 2 S., R. 2 E. A bed of coal was observed on a branch of Highland creek in section 36, same township; this bed also dips rapidly toward the Bald hill range and has not been worked.

South of the Bald hill range the seventh bed of the lower series has been worked successfully by Col. John Bell, on section 5, T. 4 S., R 1 W.

An opening is now being made in section 10, same township, by Messrs. Wheatcroft and others, and, as I have been informed, successfully worked. This bed has also been opened in several places in section 23, same township, first by Col. Bell and subsequently by Dr. Sneed and others.

It has also been penetrated by digging for water at several points on Trade-water, above Sneed's mines, but no regular workings have been made. It has been opened and regularly and successfully mined by the Messrs. Casey on section 31, T. 3 S., R. 1 W., and in section 25, T. 3 S., R. 2 W., near Caseyville; but being at this place too thin for profitable working the mine has been abandoned.

The eighth coal, as far as I have been able to ascertain, has been mined in only one place in this district, in section 9, T. 4 S., R. 1 W. This bed is of very variable quality and thickness, rising as high as six feet and sinking as low as twenty-eight inches.

The sixth or Ice House coal has, as far as ascertained, also been opened in only one point, in section 23, T. 3 S., R. 2 W.

The fifth or four-feet coal has been opened on section 14, same township, but has not been regularly mined. It is also to be found outcropping in the bed of Trade-water at the mouth of Cypress creek.

The fourth or little vein has been opened and regularly mined on section 14, T. 3 S., R. 2 W., also on section 34, T. 3 S., R. 1 W. It is worthy of note that these two beds, the fourth and fifth lying very close to each other and both being covered by a hard slowly weathering sandstone, may be traced without difficulty in nearly every part of their course through the county.

The third or "five-foot coal," or Mulford coal, has been successfully worked by James Mulford, Esq., on section 14, T. 3 S., R. 2 W.; also by Messrs. Smith, Matthias, and others, on section 15, same township; with these exceptions, no openings into this coal are known. The line of its out-crop is strongly marked throughout the entire breadth of the county.

The second, or middle coal, has been opened and worked in section 10, T. 4 S., R. 1 E., known at this point as the Thompson coal; also, in section 32, T. 4 S., R. 2 E., where it is known as the Llewellyn coal. It has also been opened, and a small amount of coal taken from it in section 13, T. 3 S., R. 1 W., and is probably the coal opened at Coal Ridge in section 36, T. 3 S., R. 1 W. It is worthy of remark, that this coal is rapidly increasing in thickness as we go eastwardly from the Ohio river, where it is scant three feet, associated with micaceous shales and shaly sandstones, while at the Thompson mine it has increased in thickness to six feet, being there covered by six feet of black bituminous argillaceous shales, (in contact with the coal,) above which are found heavy masses of limestone.

At the Llewellyn mines, and at the opening into the same coal, on the land of John Watson, the shales above the coal have thinned out to six inches, while the limestone which comes within this distance of the coal has increased to a thickness of sixteen feet.

At this mine it is also to be observed that under a thin fire-clay, of one foot in thickness, is found a light grey colored limestone, nine feet in thickness.

The first coal under the "Anvil Rock," and the first in the series of the eight workable beds of the Lower Coal Measures, has been worked for neighborhood use on section 10, T. 3 S., R. 2 W., where it is three feet in thickness.

The same coal was entered on section 18, at thirty feet from the surface, in digging a well, where it was also three feet thick, and was again observed near the Thompson mine, where it has thinned to fifteen inches of imperfect coal and "coal rash."

Thus while the second coal of the lower series has doubled its thickness, the first has diminished by more than half the thickness which it has in section 10, T. 3 S., R. 2 W. The thickness of the rocks intervening between the base of the Anvil rock and this coal, has experienced a like diminution.

It was very desirable that the third coal should have been seen, but no openings having been made into it, it was not visible. Its place, however, is well defined in this neighborhood by the post oak flat before alluded to.

On the line of the Caseyville and Morganfield road, which runs nearly with the line of the dip of the masses forming the Coal Measures of the county at this point, the out-crop of the first coal of the upper series is passed over in section 18, T. 3 S., R. 1 W. Near the line of Cypress creek, the out-crop of the second appears. Neither this coal nor the first has been worked, and they are only known by the sinking of wells which have penetrated their beds, the second coal having been thus entered at Malone's mills. The third coal of this series has been opened and worked for neighborhood use and is known as the Davis coal. The fourth coal has not been opened but may be in the valley of Cane creek; its thickness is not known but it is thought to be a coal of workable thickness.

The fifth coal or Chappel coal has been opened on section 31, T. 2 S., R. 1 W., where it is twenty-six inches thick and of good quality. The sixth or Blue coal has not been opened in this part of the county; its out-crop may be observed on the line of the road, on a tributary of Wash creek, and may be traced eastwardly until lost in the valley of Pierson's creek. No localities are known where the seventh and eighth coals have been opened south of the Bald hill range.

It has been thought proper to accompany this report with a reduced copy of map No. 1, Geological Survey, contrasted with a copy of the same territory taken from the best published map of the State. From this contrast it may be seen to what an extent error has crept into the maps of this highly favored country. Diagram No. 1 is a traced copy of Union county, as shown by the best map of Kentucky. Diagram No. 2 is a free hand reduction of map No. 1., Geological Survey, reduced to the same scale as Diagram No. 1. No stronger argument need be urged on the lamentable condition of the geography of the State than the comparison of these unpretending little figures.

Accompanying the maps are five sections showing imperfectly the great flexions of the stratification, and the effect of the Bald hill fault as now understood. The line of the first four Diagrams starts in section 20, T. 4 S., R. 1 W., and run severally north and east of north; the line of the fifth Diagram runs nearly centrally through the county. These Diagrams should be applied to the map by causing the darkest lines to coincide with the lines marking the out-crop of the productive Coal Measures.

Should the State continue this, to her very important work, I would recommend that a line be laid down as a base of operations.

By an examination of the map of Milne and Bruder, published at Louisville, it may be seen that a line running east from the mouth of Highland creek, Union county, would pass through Henderson, Daviess, Hancock, Breckinridge, Hardin, Nelson, Washington, Mercer, Jessamine, Madison, Estill; near the line dividing Powell, Estill, and Owsley; near the line dividing Breathitt and Montgomery; through Floyd and Pike, and intersecting the Virginia line near the arm of Logan.

The line thus laid down would divide the two coal fields of Kentucky into equal parts, and would give as long an east and west line as could be obtained in the State. A line of this length properly surveyed, determined, and marked would be of incalculable advantage. It would intersect the State surveys on Green, Kentucky, and Licking rivers, and as far south as the base line extended into the State would connect with the Ohio river.

In connection with the survey of such a line, if possible, such astronomical observations should be made for latitude and longitude as would determine all important places touched by it.

One of the most important branches of these observations would include those for the determination of the true meridian.

The changes of the magnetic meridian through a series of years, and its differing considerable in contiguous tracts of country, have been fruitful sources of those vexatious litigations about land lines which are so common.

Lines run eighty years or more ago, and marked by blazing or hacking trees, can now rarely be identified, for few of our forest trees retain such marks for over three quarters of a century. Even where the initial point of such a survey is found it is difficult to trace the lines, for the direction of the magnetic meridian at that time can not now be ascertained without considerable trouble.

To obviate this in future, it is proposed to erect at convenient distances along the base line, such meridian marks as may enable the surveyor to obtain, without difficulty, the true north, and therefrom the variation of the needle at the time of his survey. By noting this always, we would have at once all surveys referable to a constant line—one subject neither to shift nor change.

# INDEX.

Aaron and Boggs' coal, (Big Sandy Coal and Mining company,) analysis of, 70
Abbott's creek coal, Floyd county, 209
Agriculture, general remarks on, 373
Airdrie coal, No. 156, and section, 143, 144
Aluminium in iron, &c., 327
Amanda Furnace, section at, 188
Amanda Furnace ores, cinder, pig-iron, &c., 189, 313, 314, 315, 316, 317
Anderson's, Casey's and Big Mason creeks, 390
Anthracite, from Bocas del Torro, analysis of, 27
Anvil Rock, 45
Anvil Rock coal, upper part of first coal, analysis of, 51
Anvil Rock coal, lower part of first coal, 52
Anvil Rock coal, main five-foot, third coal, remarks on, 54
Anvil Rock coal, second coal, 56
Anvil Rock, range of hills, 387
Appendix to Chemical report, 373
Argentiferous galena, 88
Ashland main coal, below clay parting, analysis of, 69
Austin's coal, on Lewis creek, 157
Bach's (Isaac,) coal, 212
Bailey hill coal, 134
Bald hill range, 386
Barrens, remarks on, 83
Barytes, or heavy spar, Union county, 392
Bellefonte Furnace, ores, &c., 188, 291, 292
Bell's coal, Crittenden county, analysis of, 49
Bethel hills, 387
Big Mason creek, 390
Big Sandy main coal, Lawrence county, analysis of, 204
Bituminous limestone, like black band iron ore, Hopkins county, analysis of, 337
Bituminous carbonate of lime, supposed black band iron ore, Muhlenburg county, 350
Black Band ores, remarks on, 60, 139, 254
Black Band iron ore, William's landing, Muhlenburg county, analysis of, 347
Black Band iron ore, Battist creek, Muhlenburg county, analysis of, 348
Black Band iron ore, Ford's well, Muhlenburg county, analysis of, 348

Black Band iron ore, from east fork of Little Sandy, 182
Black lingular shale, 91
Black lingular shale, forest growth on, 94
Blue grass soil, Fayette county, analysis of, 276, 278
Blue limestone, composition of, 99
Blue shell limestone and marl, 98
Blue shell limestone, forest growth on, 99
Bonharbor coal of Daviess county, analysis of, 43, 151
Box Mountain Spring Coal, Hopkins county, analysis of, 53, 127
Box Mountain Sulphur Spring, 131
Brashear's salt borings, mouth of Leatherwood creek, 228
Breathitt county, section of hills near Jackson, 213
Breckinridge coal mine, 174
Breckinridge coal, its yield of oil and paraffin, 12, 62
Breckinridge coal, analysis of, 177
Buena Vista Furnace, coal and ores, 187, 287, 288, 289, 290
Buffalo Furnace ores, limestones, &c., 194, 292, 293, 294, 295, 296, 297, 298, 299, 300
Burning Spring, Clay county, 217
Butler county coal measures, 125
Cannel coal, Barrett's creek, Carter county, 270
Cannel coal, Carter county, 200
Cannel coal, Crawford's, 69
Cannel coal, head of Dorton's branch, 224
Cannel coal, opposite mouth of Troublesome creek, 211
Carburetted hydrogen, Crittenden spring, 247
Caroline Furnace, coal and ores, 191
Carter county cannel coal, 200
Casey's creek, 390
Cast iron—See pig iron.
Caverns in sub-carboniferous limestone, 81
Cerulean spring, Trigg county, 248
Chain coral and magnesia limestone, 97
Chalybeate hills, 386
Chalybeate spring, Letcher Court-house, 225
Chalybeate spring, Miller's, 219
Chalybeate springs, Perry county, 229
Chalybeate springs, Pulaski county, 237
Chalybeate spring, Robb's, in McCracken county, 114
Chalybeate springs, Rockcastle river, 238
Chalybeate waters, Mr. Swinney's, 163
Chalybeate well, Mr. Wilson's, Lexington, Fayette county, analysis of, 371
Chamelian springs, tested, 162
Chappel coal, Union county, 399
**Chemical report of Geological survey,** 251

Cinder—See Iron Furnace Slag.
Clark's mill, section at, Pond river, 136
Clay—See Fire Clay.
Clay, four miles south of Blandville, 22, 262
Clay from "Chalk Banks," 22, 335
Clay of quartenary deposits, 124
Clays, table of composition of, 369
Clear fork coal, 240
Clear creek sulphur spring, 225
Clinton Furnace, coal and ores, 187, 329, 330, 331
Clover fork of Cumberland river, 226
Coal and iron lands of Kentucky, value of, 9, 48
Coal, no workable beds of, under Archimedes and Pentremital limestones, 80
Coals, general remarks on composition and qualities, 319
Coal, Aaron and Boggs' Big Sandy coal and mining co., analysis of, 70
Coals, Anvil Rock, 45, 51, 52, 54, 56
Coal, Airdrie, (orMcLean,) Muhlenburg county, 143, 144, 352
Coals, Ashland main, analysis of, 69, 318
Coal with slate roof, Ashland, Greenup county, analysis of, 320
Coal, Atchison's, (Lacey's,) Christian county, 272
Coal, Isaac Bach's, 212
Coal, Bailey hill, 134
Coal, cannel, Barrett's creek, Carter county, analysis of, 270
Coal from Bath county, analysis of, 263
Coal, Bell's, Crittenden county, analysis of, 49
Coal, Col. John Bell's, Union county, 396
Coal, arrangement of coal beds, Big Sandy, 208
Coal, bed of Big Sandy, at forks, Pike county, 231
Coal, Big Sandy, main, analysis of, 234
Coal, Bonharbor, 43, 151
Coal, cannel-like, top of Bonharbor coal, analysis of, 44
Coal, box mountain, 53, 127
Coal, Breckinridge, 12, 62, 174, 177
Coal, Buck creek, and Bear creek, and Beaver, 234
Coal, Buena Vista Furnace, 187
Coal Measures, Butler county, 125
Coal, Messrs. Casey's, Union county, 361, 397
Coal, Chappel, Union county, 399
Coal, Clark's, Muhlenburg county, analysis of, 353
Coal, Clear fork, 240
Coal, junction of Coon and Wolf creeks, &c., 227
Coal, Croft's, 130
Coal, cannel, Crawford's, near Grayson, analysis of, 69
Coal, Cumberland river, analysis of, 234

Coal, Captain Davis', Jackfield and Pigeon Run, analysis of, 53, 128
Coal, Dorton's branch, cannel, analysis of, 224
Coal, Dr. Dudley's, Kentucky river, 216
Coal, Eades' Muhlenburg county, analysis of, &c., 138, 352
Coals of Eastern coal field, remarks on, 71
Coal, George Eaves, 137
Coal drift, Estis Hancock county, 181
Coals of Edmonson county, analysis of, 167
Coal field, Eastern, approximative boundaries of, 64
Coal field, Eastern, thickness of carboniferous rocks, 68
Coal field, boundaries of Southern, 30
Coal, Gallion's, Carter county analysis of, 270
Coal, Gamblin, Hopkins county, analysis of, 53, 129
Coal, Gavit's main, Big Sandy, analysis of, 70
Coal, Giger's hill, Greenup county, analysis of, 331
Coal, Goose creek, 218
Coal, Greenup Furnace, 193
Coal, cannel, Haddock's mine, Owsley county, analysis of, 354
Coal beds in Harlan county, 225
Coal Haven factory coal, analysis of, 161
Coal, Hawes', Hancock county, analysis of, 52
Coal, Hawesville main, analysis of, &c., 178
Coal one mile above Hazzard, Perry county, 228
Coal, Head's, Daviess county, 182
Coal, Henderson, two feet, analysis of, 44
Coal, Henderson, No. 206, analysis of, 150
Coal bed on Highland creek, Union county, 396
Coal, Hine's, on Muddy creek, Ohio county 157
Coal, Hoskins', Short mountain, analysis of, 244
Coal, Hunting-branch, main, Hopkins county, 127
Coal on Indian creek, 239
Coal, Jackfield, (or Jakefield,) Captain Davis', 53, 128
Coal, Jellico mountain, 239
Coal, Keath's, Christian county, analysis of, 271
Coals of Kentucky, table of composition of, 366
Coal, Kentucky river, North fork, 211
Coal, Kentucky river, three forks, 214
Coal, Kilgore's, Carter county, analysis of, 269
Coal, Kincheloe's Bluff, analysis of, 145
Coal, King's, 239
Coal, (Lacey's,) Atchison's, Christian county, analysis of, 272
Coal on Laurel and Sinking creeks, 240
Coal, Letcher Court-house, 225
Coal, Llewellyn mines, Union county, 398
Coal, Lewisport, 181

Coal, Lick, 132
Coal, Little Sandy river, 185
Coal beds, Log mountain, 222
Coal, Marcus, 137
Coal, Col. Martin's, analysis of, 208
Coal, Martin, 138
Coal, McHenry's, Big Sandy, analysis of, 70
Coal, McLean or Airdrie, 143
Coal bank, McNairy's, Pond river, 135
Coal ridge between Meadow and Sinking creeks, 243
Coal measures, 29
Coal measures, Eastern coal field, dip of, 65
Coal measures, an offset of, in Grayson county, 170
Coal measures of Greenup, Carter, and Lewis counties, 182
Coal measures of Hopkins, Muhlenburg, McLean, and Butler counties, 125
Coal measures of Henderson, Daviess, Ohio, Butler, Edmonson, Grayson, Hancock and Breckinridge, and part of Warren counties, 150
Coal measures of Lawrence, Johnson, Floyd, Pike, Letcher, Perry, Breathitt, Harlan, Clay, Knox, Whitley, and part of Owsley, Laurel, Pulaski, Wayne and Clinton counties, 201
Coal measures, lower, order of superposition of, 45
Coal measures of McLean county, 125
Coal measures, total thickness of, and number of beds, 43
Coal measures in Union county, 393
Coal measures, upper, order of superposition of, 40, 42
Coal, Mick's branch, 216
Coal, Mr. Miller's, 137, 138
Coal, James Mulford's, Union county, 397
Coal, Naut's, on Sandy creek, 160
Coal, Paint creek, 210
Coal, Peach Orchard, analysis of bottom part of, 69
Coal, Pennsylvania Furnace, Greenup county, 191
Coal, four-foot, Pennsylvania Furnace, Greenup county, analysis of, 288
Coal, (main,) of centre of Perry county, 227
Coal seven miles below Pikeville, 232
Coal, (Shelby fork of Big Sandy,) Pike county, 230
Coal, Pleasant Run, 133
Coal, Pitman range of hills, Pulaski county, 237
Coal, Pittsburg, analysis of, 363
Coal, Pond river, Hopkins county, 134, 340
Coal bed, head of Pond fork, Union county, 395
Coal, Poplar Chalybeate mountain, 245
Coal, &c., at Prestonsburg, 206
Coal region of Pulaski county, 233, 237
Coal, (under the conglomerate,) in Pulaski and Rockcastle counties, 68

Coals, Raccoon Furnace, Greenup county, analysis of, 195, 311, 312
Coal, Richland creek, 131
Coal, Roberts', 52, 140, 142
Coal, Robinson's, Hopkins county, analysis of, 339
Coal, Rockcastle river, 237
Coal on Rockhouse creek, 229
Coal, Russey's, Muddy creek, 160
Coal, Pardon Sheldon's, Butler county, analysis of, 265
Coal, Sloan's hill and Short mountain, 244
Coal, Sneed's mines, Crittenden county, analysis of, &c., 275, 397
Coal, Star Furnace, 186
Coal mine, Taylor's, Green river, section of, 158
Coal, Terry's, analysis of, Hopkins county, 126
Coal, Thompson, Union county, 397
Coal, Three-mile creek, York bed, 203
Coal mines, Todd & Crittenden's, South fork Kentucky river, 215
Coal, Todd & Crittenden's, Owsley county, analysis of, 354
Coals on Trade-water river, 125, 394
Coal in Tred's branch of Laurel, 226
Coal, cannel, Troublesome creek, 211
Coals from Tug fork of Big Sandy, 202, 203
Coal from Tygerts coal bank, Butler county, analysis of, 265
Coal from Vincent branch of Tug fork, Big Sandy, 203
Coal, Watts' creek, 240
Coal, Messrs. Wheatcroft's and others, Union county, 396
Coal, Whitley county, opposite Williamsburg, 239
Coal, Wright's mountain, Hopkins county, analysis of, 339
Coal, Wolf hill, Daviess county, 44, 154
Cook's coal, analysis of, 43
Coralline Falls limestone, 95
Coralline Falls limestone, growth of timber on, 97
Coralline Falls limestone, galena in, 97
Crab Orchard creek, 390
Crawford's cannel coal, (near Grayson,) analysis of, 69
Crittenden springs, tested, 247
Croft's, Martin, coal, 130
Cumberland river, above the falls, 233
Cumberland river coal, analysis of, 234
Cumberland river iron furnace and ores, 240
Cumberland Falls, supposititious silver ore, 235
Cypress creek, 389
Cypress creek of the Ohio, 390
Davis' (Capt.) Jackfield coal, Hopkins county, analysis of, 53, 128
Davis' (Capt.) Pigeon Run coal, analysis of, 53, 128
Detailed geologico-topographical survey, 100

Dorton's branch cannel coal, analysis of, 224
Dudley's, (Dr.,) coal. Kentucky river, 216
Eade's coal, (No. 157,) 138
Eagle creek or Jerusalem school-house range of hills, 387
Earthquake of 1811, 117
Eaves', (George,) coal, 137
Edmonson county, section of geology of Northern part of, 164
Edmonson county coals, analyses of, 167
Edmonson county, best soil of table land of, 168
Estis coal drift, Hancock county, 181
Everley's ridge, section of coal measures in, 147
Falls of Cumberland, section at, 235
Ferruginous limestone, Clinton furnace, Greenup county, analysis of, 331
Ferruginous limestone, Christian county, analysis of, 274
Ferruginous limestone, Green rock, Carter county, 269
Ferruginous limestone, New Hampshire Furnace, Greenup county, analysis of, 323
Fire-clays, 61, 369
Fire clays, Ashland, Greenup county, analyses of, 332
Fire-clay, Casey's mines, Union county, analysis of, 361
Flats and low lands, Union county, 391
Fluor spar, 87
Franklin coal, 130
Freestone for building, 232
French Island coal, analysis of, 45
Gamblin coal, Hopkins county, analysis of, 53, 129
Gavits' main coal, Big Sandy, analysis of, 70
Geology of Union county, 392
Gravel bank, flats of Cypress creek, 148
Grayson county, offset of coal measures in, 170
Grayson springs, 170
Green river manufacturing and coal company mines, section at, 141
Greenup Furnace ores, coals, &c., 193, 300, 301, 302, 303, 304, 305
Grey band iron ore, Muhlenburg county, analysis of, 319
Goose creek salt works, 67
Goose creek salt waters, coals, &c., 218
Harlan county coal beds, 225
Hawes' coal, Hancock county, analysis of, 52
Hawesville main coal, analysis of, and remarks on, 178
Head's coal, Daviess county, 182
Hearthstones, New Hampshire Furnace, 198
Henderson coal company shaft, at Henderson, Kentucky, section of, 36
Henderson coal, No. 206, analysis of, 150
Henderson two-foot coal, analysis of, 44
Highland creek, 390

Hines' coal, on Muddy creek, Ohio county, - - - - - - 157
Holloway boring, Henderson county, section of, - - - - 32
Hopkins county coal measures, - - - - - - - - 125
Hoskin's coal, Short mountain, analysis of, - - - - - - 244
Hunting branch main coal, Hopkins county, analysis of, - - - 127
Ice-house coal, remarks on, and analysis of, - - - - - - 51, 55
Industry mines, Big Sandy coal and manufacturing company, section at, - - - - - - - - - - - - - - 205
Iron—See Pig-iron.
Iron Furnaces on Cumberland river, - - - - - - - 246
Iron Furnace Slag, Amanda Furnace, Greenup county, analysis of, - 316
Iron Furnace Slag, Bellefonte Furnace, Greenup county, analysis of, 292
Iron Furnace Slag, Buena Vista Furnace. Greenup connty, analysis of, 290
Iron Furnace Slags, Buffalo Furnace, Greenup county, analyses of, - 298, 299
Iron Furnace Slag, Greenup Furnace, analysis of, - - - - - 305
Iron Furnace Slags, of Greenup county Furnaces, remarks on, - - 72
Iron Furnace Slags, New Hampshire Furnace, Greenup county, analyses of, - - - - - - - - - - - - 324, 325
Iron Furnace Slags, Pennsylvania Furnace, Greenup county, analyses of, - - - - - - - - - - - - - - 286, 287
Iron Furnace Slags, Raccoon Furnace, Greenup county, analyses of, - 309
Iron Furnace Slags, table of composition of, - - - - - - 367
Iron ore, Alexander's, McCracken county, analysis of, - - - 344
Iron ore, Backster's bank, Kelly's Furnace, Lyon county, analysis of, 344
Iron ore, Bath county, Messrs. Carter's Furnace, analysis of, - - 263
Iron ore, "best limestone ore," Amanda Furnace, Greenup county, analysis of, - - - - - - - - - - - 315
Iron ore, best ore, Sandy Furnace, Carter county, analysis of, - - 268
Iron ore, "better quality impracticable ore," Pennsylvania Furnace, Greenup county, analysis of, - - - - - - - 283
Iron ore, "big block ore," Greenup Furnace, analysis of, - - - 301
Iron ores, black band, - - - - 60, 139, 182, 254, 347, 348, 349
Iron ore, "black bed," Greenup Furnace, analysis of, - - - 303
Iron ore, "black vein," Buena Vista Furnace, Greenup county, analysis of, - - - - - - - - - - - - 288
Iron ore, "block kidney ore," Buffalo Furnace, Greenup county, analysis of, - - - - - - - - - - - - - 294
Iron ores, "block ores," New Hampshire Furnace, Greenup county, analyses of, - - - - - - - - - - - 320, 321
Iron ore, "block ore," Pennsylvania Furnace, Greenup county, analysis of, - - - - - - - - - - - - - 280
Iron ores, "block ores," Raccoon ore banks, Greenup county, analyses of, - - - - - - - - - - - - - - 306, 307
Iron ore, "blue block ore," Amanda Furnace, Greenup county, analysis of, - - - - - - - - - - - - - 315

Iron ore, "blue limestone ore," Bellefonte Furnace, Greenup county, analysis of, 291
Iron ore, "blue ore," near Clinton Furnace, Greenup county, analysis of, 330
Iron ores, Buena Vista Furnace, 187
Iron ore, Bunt's gap, Hopkins county, analysis of, 336
Iron ore, (carbonate,) Butler county, analysis of, 264
Iron ore, (carbonate,) Muhlenburg county, analysis of, 350
Iron ore, (carbonate,) White Oak branch of Rockcastle river, 241
Iron ore, Chandler bank, Suwannee Furnace, Lyon county, analysis of, 343
Iron ore, clay ironstone, Muhlenburg county, analysis of, 346
Iron ores at Coal Haven and head of French Island, 60
"Iron ores" considered "impracticable," 72, 75
Iron ores from Cumberland river, 246
Iron ore, dark variety of "little block ore," Buffalo Furnace, Greenup county, analysis of, 294
Iron ore, "earthy kidney ore," Buena Vista Furnace, Greenup county, analysis of, 289
Iron ore, Falls of Blain, 202
Iron ore, "flag ore," Greenup Furnace, analysis of, 300
Iron ores, Greenup Furnace, 193
Iron ores of Greenup and Carter, value of, 199
Iron ores, grey band, Muhlenburg county, 349
Iron ore, "grey block ore," Buffalo Furnace, Greenup co, analysis of, 296
Iron ore, "grey limestone ore," Greenup Furnace, analysis of, 302
Iron ore, Hawes' ridge, Muhlenburg county, analysis of, 138, 345
Iron ore, "honey-comb ore," Amanda Furnace, Greenup county, analysis of, 314
Iron ore, "impracticable hard limestone ore," Pennsylvania Furnace, analysis of, 284
Iron ore, "impracticable part of limestone ore," Pennsylvania Furnace, analysis of, 285
Iron ore, "impure limestone," Buffalo Furnace, Greenup county, analysis of, 296
Iron ore, Jenkins' ore bank, Muhlenburg county, analysis of, 139, 345
Iron ores, Kenton Furnace, 197
Iron ore, "Kidney ore," New Hampshire Furnace, Greenup county, analysis of, 321
Iron ore, Kincheloe's bluff, Muhlenburg county, analysis of, 346
Iron ores, Laurel Furnace, 196
Iron ores, "limestone ores," Clinton Furnace, Greenup co., analyses of, 329, 330
Iron ores, limestone ores, Greenup Furnace, analyses of, 303, 304
Iron ore, "limestone ore," New Hampshire Furnace, Greenup county, analysis of, 322
Iron ores, limestone ores, Pennsylvania Furnace, analyses of, 281, 282
Iron ores from Lithostrotion beds of sub-carboniferous limestone, 85
Iron ore, "little block ore," Buffalo Furnace, Greenup co., analysis of, 293

Iron ore, "little block ore," Pennsylvania Furnace, analysis of, - 281
Iron ores, "main block" ores, Buffalo Furnace, Greenup county, analyses of, - - - - - - - - - - - - - - 293, 295
Iron ore, "main upper kidney ore," Raccoon ore banks, analysis of, - 308
Iron ores on Meadow creek, Watts' creek, &c., &c., - - - 240
Iron ores in Muhlenburg and Hopkins county, lower coal measures, - 59
Iron ores, Mt. Savage Furnace, Greenup county, analyses of, - - 328
Iron ores, Pennsylvania Furnace, Greenup county, - - - - 191
Iron ore, "poor sandy ore," New Hampshire Furnace, Greenup county, analysis of, - - - - - - - - - - - 322
Iron ores, Raccoon Furnace, Greenup county, - - - - - 195
Iron ore, "red and blue block," Amanda Furnace, Greenup county, analysis of, - - - - - - - - - - - 314
Iron ore, "red ochre," Greenup Furnace, analysis of, - - - 301
Iron ores, Rough and Ready, - - - - - - - - - 184
Iron ore, "rough sandy block ore," Buffalo Furnace, Greenup county, analysis of, - - - - - - - - - - - 295
Iron ore, "shot ore," Ashland, Greenup county, analysis of, - - 317
Iron ores, Sneed's mines, Crittenden county, analysis of, - - - 274, 275
Iron ore, "soft limestone ore," Raccoon ore banks, Greenup county, analysis of, - - - - - - - - - - - 306
Iron ore, speckled, New Hampshire Furnace, analysis of, - - 198
Iron ores, Stewart's creek, Hopkins county, analyses of, - - - 336, 338
Iron ore, "Sugar creek," Hopewell Iron Works, Livingston county, analysis of, - - - - - - - - - - - 341
Iron ores, tables of composition of, - - - - - - - - 364, 365
Iron ore, Top-hill ore, Pennsylvania Furnace, Greenup county, analysis of, - - - - - - - - - - - - - 282
Iron ore, Tygert's creek, Carter county, - - - - - - 200, 268
Iron ore, Mr. Wallace's, Carter county, analysis of, - - - 267
Iron ore, Williams' landing, Green river, - - - - - 60, 347
Iron ore, "yellow kidney ore," Amanda Furnace, Greenup county, analysis of, - - - - - - - - - - - 313
Iron ore, "yellow kidney ore," Buena Vista Furnace, Greenup county, analysis of, - - - - - - - - - - - 289
Ironstones between the little vein and Well coal, - - - - 59
Ironstone, calcareous, used at Sandy Furnace, analysis of, - - 78
Ironstones of eastern coal field, - - - - - - - 71
Ironstones in shales over ice-house coal, analysis of, - - - - 57, 58
Island district, on Cypress creek, - - - - - - - 147, 148
Jackfield coal, Capt. Davis', analysis of, - - - - - - 53, 128
Jellico Mountain, - - - - - - - - - - - - 239
Kenton Furnace, ores, &c., - - - - - - - - - 197
Kentucky river, north fork, coal, - - - - - - - 211
Kentucky river, three forks, coal, - - - - - - - 214
Kincheloe's Bluff coal, (No. 196,) analysis of, - - - - 145

Kincheloe's Bluff, or Lewisport, Green river, section at, 145
King's coal, 239
Laurel Furnace ores, &c., 196
Lead and zinc ores, 87
Lead ores, argentiferous, 88
Letcher C. H. coal, 225
Lewellyn coal mines, Union county, 398
Lewisport coal, 181
Lick coal, No. 92 of collection, analysis of, 132
Lignite and brown coal of quaternary deposits, 25, 26, 116, 262
Limestones, 60
Limestone, Dr. Hopson's Marble, Trimble county, analysis of, 358
Limestone, bituminous, supposed black band ore, Muhlenburg county, 350
Limestone, ferruginous, Christian county, analysis of, 274
Limestone, ferruginous, Clinton Furnace, Greenup county, analysis of, 331
Limestone, ferruginous, New Hampshire Furnace, Greenup county, analysis of, 323
Limestone, ferruginous, like black band iron ore, Hopkins county, analysis of, 337
Limestone, ferruginous, Sandy Furnace, Carter county, analysis of, 269
Limestone, magnesian, (hydraulic,) analysis of, 273
Limestone, table of composition of, 368
Limestones, used for flux at the Greenup Furnaces, 75, 285, 292, 297, 298, 304, 308
Limestone, used as a flux, Bellefonte Furnace, Greenup county, analysis of, 292
Limestones, used as flux, Buffalo Furnace, Greenup county, analyses of, 297, 298
Limestone, used as flux, Greenup Furnace, analysis of, 304
Limestone, used as flux, New Hampshire Furnace, Greenup county, analysis of, 323
Limestone, used as a flux, Pennsylvania Furnace, Greenup county, analysis of, 285
Limestone, used as a flux, Raccoon Furnace, Greenup county, analysis of, 308
Limonites—see iron ores.
Limonite and other iron ores, Meadow creek and Watts' creek, 240
Linn Camp, section on, 220
Lithostrotion bed of sub-carboniferous limestone, or "Barren" limestone, 82
Little Sandy river coal, 185
Log Mountain coal beds, 222
London, Laurel county, formation at, 241
Lost creek, 390
Lower coal measures, order of superposition, 45
Magnesian limestone, Christian county, analysis of, 273
Mammoth Cave, 169

Map of Union and Crittenden counties, scale of, - - - - - 385
Marble, Conchitic, Dr. Hopson's, Trimble county, - - - - - 358
Marcus coal, - - - - - - - - - - - - - - - 137
Martin coal, - - - - - - - - - - - - - - - - 138
Martin's, Col., coal, analysis of, - - - - - - - - - - 208
McHenry's coal, Tug Fork, Big Sandy, analysis of, - - - - 70
McLean or Airdrie coal, (No. 192,) - - - - - - - - 143
McLean county coal measures, - - - - - - - - - 125
McNairy's coal bank, Pond river, section at, - - - - - - 135
Megalonyx Bones, letter to Prof. Joseph Leidy, - - - - - 22
Mick's branch coal, - - - - - - - - - - - - 216
Milk sickness, - - - - - - - - - - - 20, 95, 102, 159
Miller's (Mr.) coal, - - - - - - - - - - - - 137, 138
Miller's (H. G.) mineral spring, examination of, - - - - - 219
Millstone grit, quarries, - - - - - - - - - - - 63
Mineral pitch or tar, Edmonson county, analysis of, - - - - 166
Mineral waters, on Barnett's creek, - - - - - - - - 156
Mineral waters, on Clear creek, Sulphur spring, - - - - - 225
Mineral waters, Crittenden spring, sulphur, - - - - - - 247
Mineral waters, Fayette county, - - - - - - - - - 372
Mineral waters, Letcher C. H., chalybeate, - - - - - - 225
Mineral waters, Miller's, chalybeate, - - - - - - - - 219
Mineral waters, Perry county, chalybeate, - - - - - - 229
Mineral waters, Pulaski county, chalybeate, - - - - - - 237
Mineral waters, Robb's, McCracken county, chalybeate, - - - - 114
Mineral waters, Rockcastle river, chalybeate, - - - - - - 238
Mineral waters, Social hill, sulphur, - - - - - - - - 148
Mineral waters, Mr. Swinney's, chalybeate, - - - - - - 163
Mineral waters, Mr. Wilson's, Lexington, chalybeate, - - - - 371
Mount Savage Furnace ores, &c., - - - - - - - - 185, 328
Mount Savage Furnace, Stinson ore banks, section of, - - - - 185
Muhlenburg county coal measures, - - - - - - - - - 125
Mulford's four-foot coal, analysis of, - - - - - - - - 50
Mulford's "little vein," analysis of, - - - - - - - - 50
Mulford's "little vein," cannel part, analysis of, - - - - - 50
Mulford's middle coal, analysis of, - - - - - - - - - 51
Mulford's main or five-foot coal, Union county, analysis of, - - 49
Naut's coal, on Sandy creek, - - - - - - - - - - 160
New Hampshire Furnace ores, &c., 77, 197, 198, 320, 321, 322, 323, 324, 325, 326, 327
New Hampshire Furnace, speckled ore, analysis of, - - - - - 77, .98
Nolin creek, Edmonson county, section at, - - - - - - 164
Nomenclature of Kentucky Geological formations, - - - - - 16
Northern Kentucky mines, section at, - - - - - - - - 207
Oil Spring branch, petroleum, - - - - - - - - - 210
Paint creek coal, - - - - - - - - - - - - - 210

Peach Orchard coal, bottom part, analysis of, 69
Pennsylvania Furnace ores, coal, &c., 72, 75, 191, 280, 281, 282, 283, 284, 285, 286, 287, 288
Petroleum on Oil Spring branch, 210
Phosphoric acid, re-examination of soils for, 378
Pigeon Run coal, Capt. Davis', analysis of, 128
Pig-iron, Amanda Furnace, Greenup county, analysis of, 317
Pig-iron, Bellefonte Furnace, Greenup county, analysis of, 292
Pig-iron, Buena Vista Furnace, Greenup county, analysis of, 290
Pig-iron, Buffalo Furnace, Greenup county, analyses of, 299, 300
Pig-iron, Greenup Furnace, analysis of, 305
Pig-iron, New Hampshire Furnace, Greenup county, analyses of, 325, 326
Pig-iron, Pennsylvania Furnace, Greenup county, analysis of, 287
Pig-iron, Raccoon Furnace, Greenup county, analyses of, 310, 311
Pig-iron, from Sandy Furnace, analysis of, 184
Pig-iron, table of composition of, 367
Pittsburg coal, analysis of, 363
Pleasant Run coal, 133
Pond fork valley, 391
Pond river coal, (No. 137,) 134, 340
Poplar Chalybeate mountain coal, 245
Prestonsburg coal, &c., 206
Quaternary deposits, 17
Quaternary deposits, order of superposition, at the "Iron and Chalk banks," 22
Quaternary deposit, (silico-calcareous,) analysis of, near Columbus, 18
Quaternary deposit, silicious, 20
Quaternary deposits, soils from, 27
Quaternary formation of McCracken, &c., &c., &c., 113
Quaternary formation, sections of, 116, 120, 122
Raccoon Furnace coal, ores, &c., 195, 306, 307, 308, 309, 310, 311, 312, 313
Red lands and sub-soil of southern Kentucky, 88
Red ochre, Greenup Furnace, analysis of, 301
Reedy hills, Grayson county, 172
Reel-foot lake, 117
Richland creek coal, 131
Robb's Chalybeate spring, McCracken county, 114
Roberts' coal, (No. 191,) Muhlenburg county, 52, 140, 142
Rockcastle river, narrows of, coal, &c., 237
Rough and Ready ore bed, 184
Rough creek, Grayson county, falls of, 173
Russey's coal, on Muddy creek, 160
Salt borings, Brashears, 228
Salt borings, near Hazzard, Perry county, 228
Salt borings, Whitesburg, 229
Salt efflorescence and licks, Shelby fork, Big Sandy, 231

Salt river knobs, growth on, - - - - - - - - 91
Salt water, junction of Lost and Troublesome creeks, - - - 211
Salt water and other mineral waters, Barnett's creek, - - - 156
Salt water, mouth of Leatherwood creek, - - - - - - 228
Salt well, on Big Sandy, near Kane farm, - - - - - - 201
Salt works, Goose creek, - - - - - - - - - - 67, 218
Samuel's coals, (McLean Co.,) - - - - - - - - 149
Sandstones of coal measures, for building, - - - - - 62
Sandstones, hearthstones, New Hampshire Furnace, Greenup county,
analysis of, - - - - - - - - - - 327
Sandstone, hearthstone, Raccoon Furnace, Greenup county, analysis of, 313
Sandstone, sub-carboniferous, - - - - - - - - 89
Sandstone suitable for hearthstones, Edmonson county, - - - 168
Sandy Furnace, calcareous and top hill ores, analysis of, - - - 183
Sandy Furnace ores, &c., &c., - - - - - 78, 183, 184, 268, 269
Scatters of Cypress, - - - - - - - - - - - 386
Section at Amanda Furnace, - - - - - - - - - 188
Section in Breathitt county, near Jackson, - - - - - - 213
Section at Clarke's mill, Pond river, - - - - - - - 136
Section, clover fork of Cumberland river, - - - - - 226
Section of formations of northern part of Edmonson county, - - 164
Section of coal measures, Everley's ridge, - - - - - - 147
Section at south Carrollton, - - - - - - - - - 146
Section, falls of Cumberland river, - - - - - - - 235
Section at Green River Manufacturing and Coal Company's Mines, - 141
Section at forks of Green and Barren rivers, - - - - - - 161
Section of Holloway boring, Henderson county, - - - - - 32
Section at Industry mines, - - - - - - - - - - 205
Section south fork Kentucky river, - - - - - - - - 215
Section at Kincheloe's Bluff or Lewisport, (Green river,) - - - 145
Section on Linn camp, - - - - - - - - - - - 220
Section at McNairy's coal bank, Pond river, - - - - - - 135
Section at Nolin creek, Edmonson county, - - - - - - 164
Section of quaternary deposits of McCracken county, &c., - 116, 120, 122
Section seven miles below Pikeville, - - - - - - - - 232
Section at Stinson ore banks, Mt. Savage Furnace, - - - - - 185
Section at Taylor's coal mine, Green river, - - - - - - 158
Section at Todd & Crittenden's coal mines, - - - - - - 215
Section at William's Landing, Green river, - - - - - - 143
Section at Joel Wright's to the top of Sounding gap, - - - 229
Septaria, calcareous, Morgan county, - - - - - - - 210
Short mountain coal, - - - - - - - - - - - 244
Silver ore, suppositious, Cumberland falls, - - - - - - 235
Sink holes in Barren limestone region, - - - - - - - 84
Slate quarry, Hopkins county, - - - - - - - - 133
Slate, Ring creek, Perry county, - - - - - - - - 229

Sloan's hill coal, 244
Social hill mineral water, 148
Soils from Ballard county, analyses of, 259, 261, 379
Soils, from blue limestone formation, remarks on, 100, 374
Soil, (ridge land,) Butler county, analyses of, 266, 379
Soil, southern part of Christian county, analyses of, 272, 379
Soils from the coal measures, remarks on, 63
Soil from Daviess county, 153, 379
Soil, of Edmonson county, best of table land, 168, 379
Soil, virgin, Fayette county, analysis of, 276, 379
Soil, old field, Fayette county, analysis of, 276, 379
Soil, Fulton county, analysis of, 279, 379
Soil, under gravel bed, Fulton county, analysis of, 280, 379
Soil and forest growth, Graves county, 121
Soil, Henderson county, analysis of, 333, 379
Soil, white, of Bayou de Chienne, Hickman county, analysis of, 334, 379
Soils, "white earth," Hickman county, analyses of, 334, 335, 379
Soil and sub-soil, Hopkins county, analysis of, 340, 379
Soil, Livingston county, analysis of, 341, 397
Soil, southern part Logan county, analysis of, 342, 379
Soil, coal region, Muhlenburg county, analysis of, 351, 379
Soils from quaternary deposits, 27
Soils, re-examination of, for phosphoric acid, 378
Soil, Simpson county, analysis of, 355, 379
Soil of sub-carboniferous or knob sandstone, 89
Soils, table of composition of, 370
Soil and sub-soil, Todd county, analysis of, 357, 379
Soil, (red clay sub-soil,) Todd county, analysis of, 356, 379
Soil, Trigg county, analysis of, 360, 379
Soils, Union county, 392
Soil, Warren county, analysis of, 361, 379
Sounding gap, section at, 229
South Carrollton, section at, 146
Southern coal field, boundaries of, 30
Speckled iron ore, New Hampshire Furnace, analysis of, 77, 198
Springs, Union county, 392
Spring waters injurious, &c., Hickman county, 19
Stanley coal bank, 137
Star Iron Furnace coal, and ores, 186
Stinson ore banks, Mt. Savage Furnace, section of, 185
Sub-carboniferous limestone, 79
Sub-carboniferous sandstone, 89
Sub-carboniferous limestone of Crittenden, Livingston, Lyon, Caldwell, and Trigg counties, 246
Sulphur spring, Box mountain, 131
Sulphur spring, Cerulean, Trigg county, 248

Sulphur spring, Clear creek, 225
Sulphur springs, Grayson county, 170
Sulphur spring hills, 366
Sulphur spring of Livingston county, 243
Sulphur spring, Social hill, 143
Sulphuret of zinc, Crittenden county, analysis of, 276
Sulphur water, Crittenden spring, 247
Swift mine, 222
Swinney's, Mr., Chalybeate spring tested, 163
Table of composition of Kentucky clays, 369
Table of composition of Kentucky coals, 366
Table of composition of Kentucky iron furnace slags, 367
Table of composition of Kentucky iron ores, 364, 365
Table of composition of Kentucky limestones, 368
Table of composition of Kentucky pig-iron, 367
Table of composition of Kentucky soils, 370
Table of mineral matter removed from the soil by crops, 377
Tar, (mineral,) or pitch, from Edmonson county, analysis of, 166
Tar spring, Breckinridge county, Tar creek, 174
Taylor's coal mine, Porter's landing, Green river, section of, 153
Technical terms, 378
Terry's coal, analysis of, Hopkins county, 126
Thoroughfare between Green river and Cypress creek, 148
Three-mile creek, York bed of coal, 203
Todd & Crittenden's mines, south fork Kentucky river, section at, 215
Topographical Geological report, 381
Topographical survey, method adopted in, 383
Trade-water river, 389
Trade-water river coals, 125, 394
Troublesome creek, cannel coal, and salt water, 211
Tug fork, Big Sandy, coals on, 203
Tygert's creek iron ore, 200
Union county, Geology of, 392
Union county, detailed survey of, remarks on, 106
Upper coal measures, order of superposition, 40, 42
Vegetables, mineral elements, of 375
War gap, Pine mountain, 226
Water, supposed to cause milk sickness, 159
Watt's creek coal, 240
Whitesburg, salt borings, 229
William's landing, Green River, section at, 143
William's landing, iron ore at, 60
Wolf hill coal, Daviess county, (No. 189,) analysis of, 44, 154
York bed of coal, Three-mile creek, 203
Zinc ore, Crittenden county, analysis of, 276

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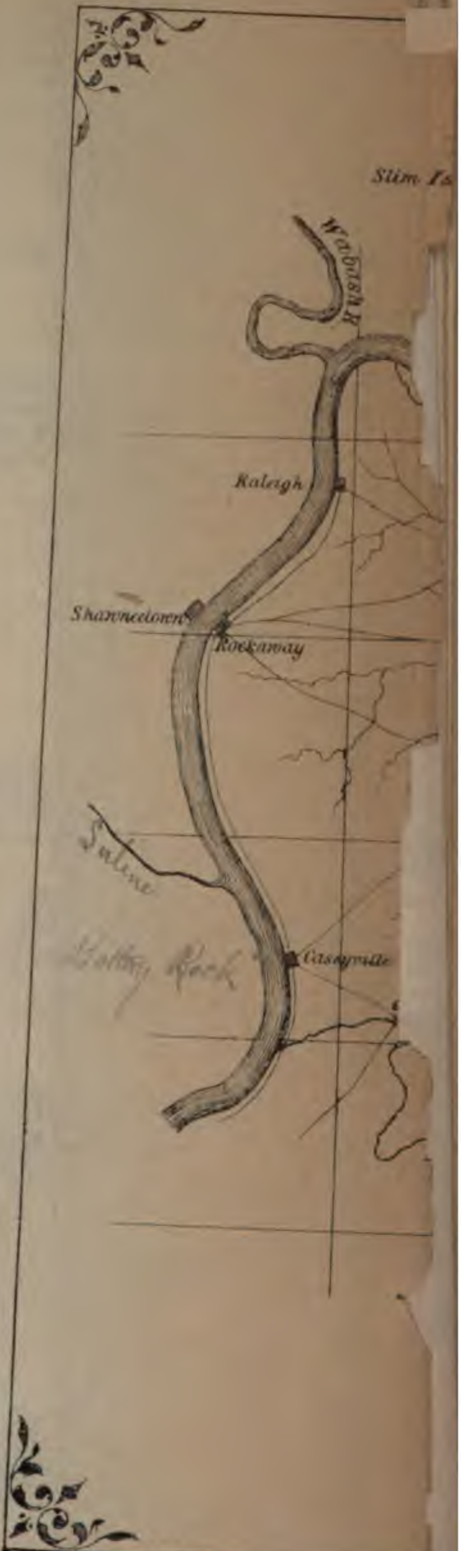
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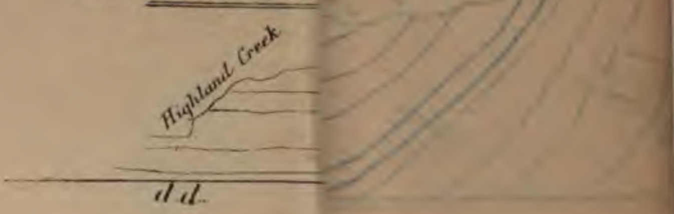

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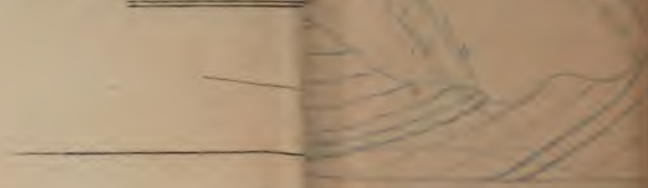

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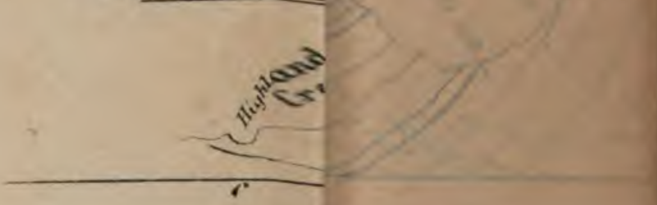

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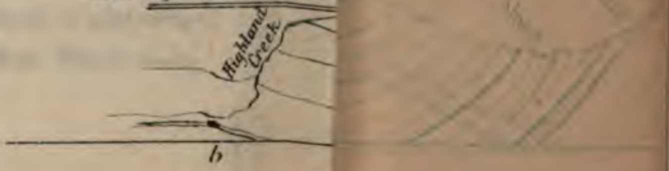

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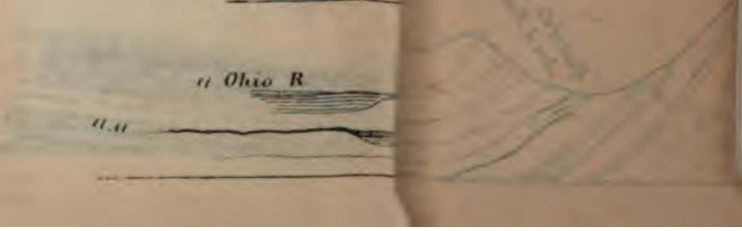
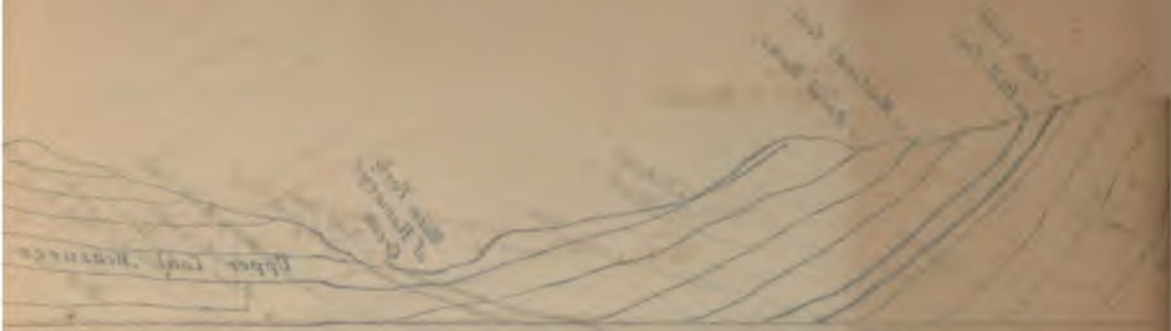
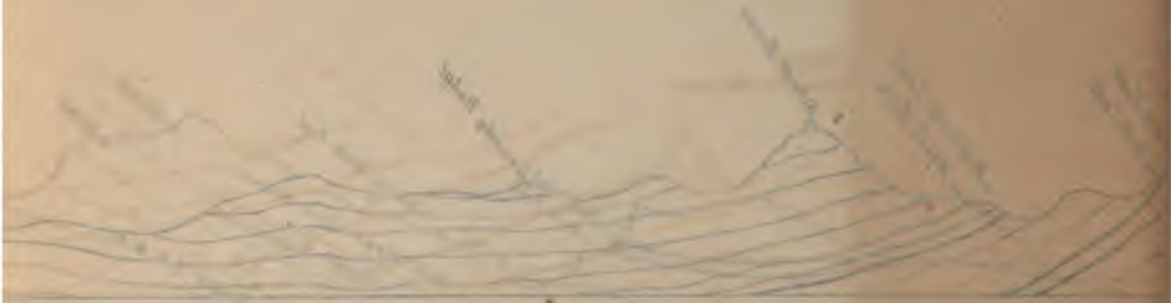
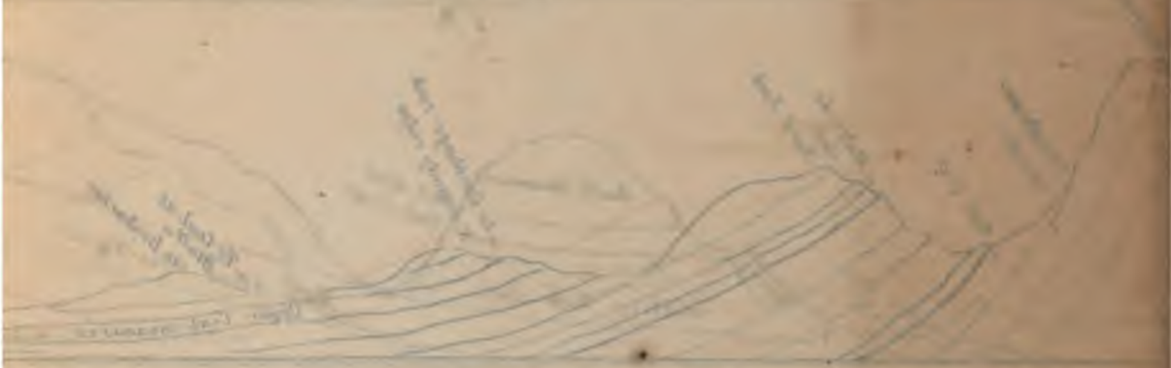
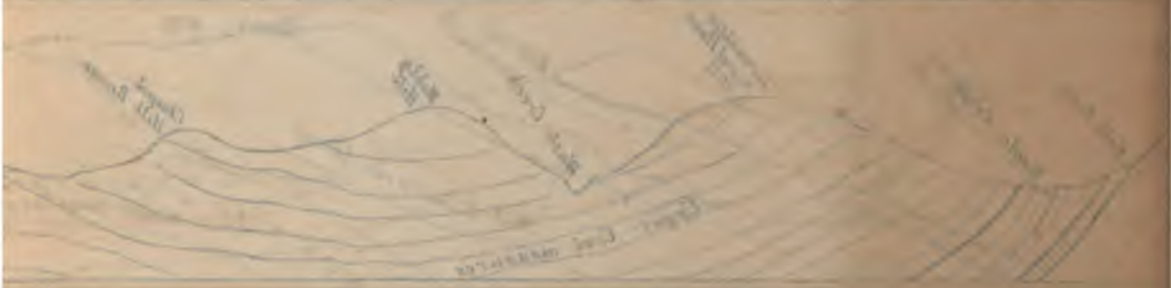
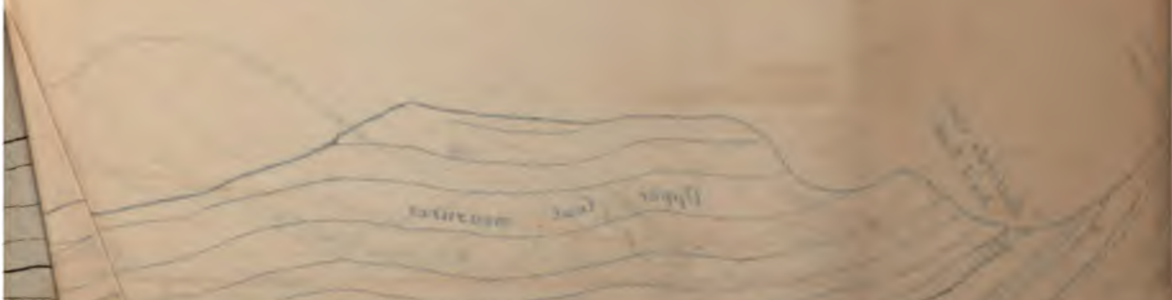




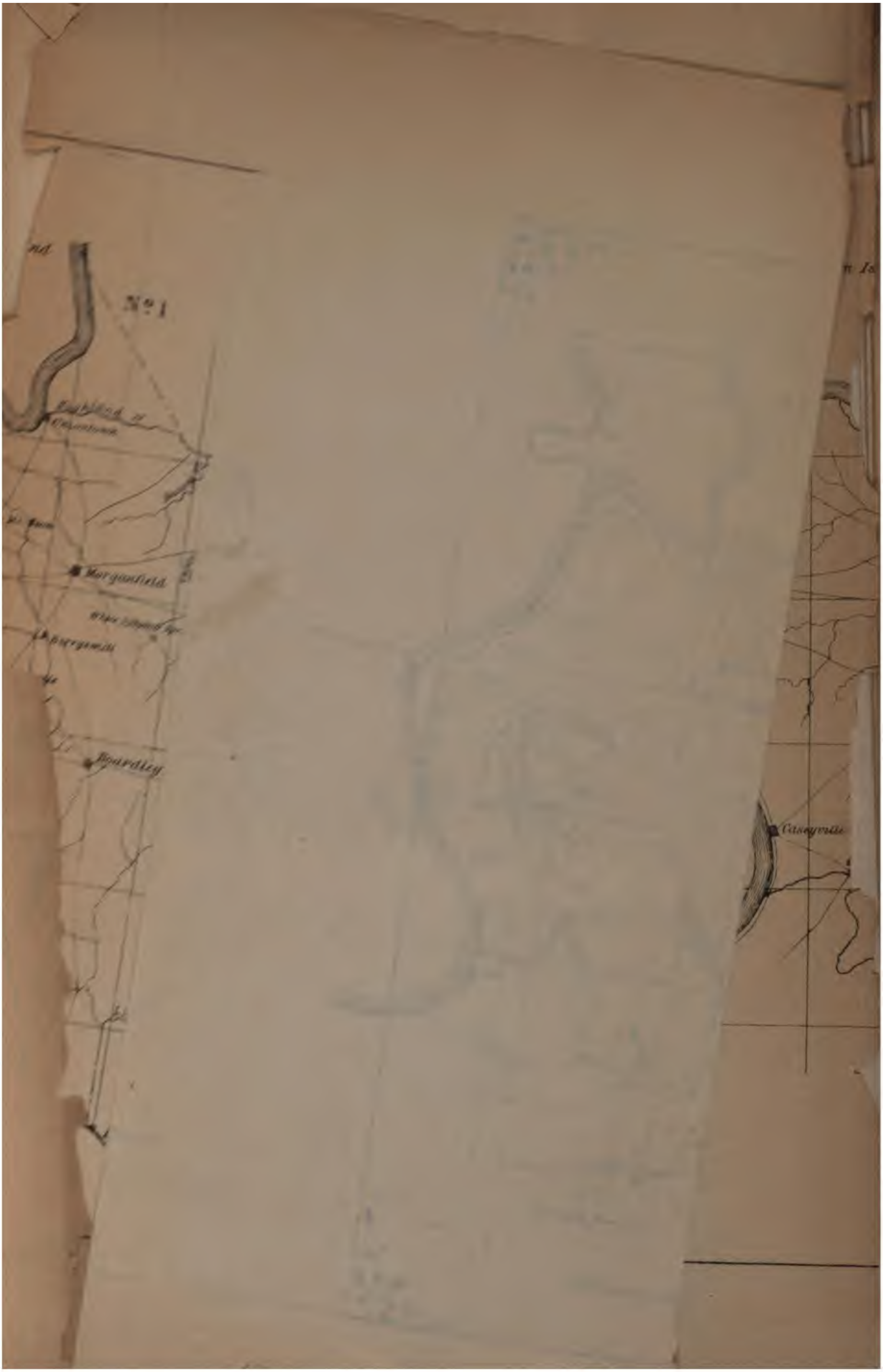








Sulphur spring, Clear creek, - - - - - - - - - - 225
Sulphur springs, Grayson county, - - - - - - - - 170
Sulphur spring hills, - - - - - - - - - - - 386
Sulphur spring of Livingston county, - - - - - - 243
Sulphur spring, Social hill, - - - - - - - - - 143
Sulphuret of zinc, Crittenden county, analysis of, - - - - - 276
Sulphur water, Crittenden spring, - - - - - - - - 247
Swift mine, - - - - - - - - - - - - - 222
Swinney's, Mr., Chalybeate spring tested, - - - - - - 163
Table of composition of Kentucky clays, - - - - - - 369
Table of composition of Kentucky coals, - - - - - - 366
Table of composition of Kentucky iron furnace slags, - - - - 367
Table of composition of Kentucky iron ores, - - - - - - 364, 365
Table of composition of Kentucky limestones, - - - - - 368
Table of composition of Kentucky pig-iron, - - - - - - 367
Table of composition of Kentucky soils, - - - - - - 370
Table of mineral matter removed from the soil by crops, - - - 377
Tar, (mineral,) or pitch, from Edmonson county, analysis of, - - 166
Tar spring, Breckinridge county, Tar creek, - - - - - - 174
Taylor's coal mine, Porter's landing, Green river, section of, - - 158
Technical terms, - - - - - - - - - - - - 378
Terry's coal, analysis of, Hopkins county, - - - - - - 126
Thoroughfare between Green river and Cypress creek, - - - 148
Three-mile creek, York bed of coal, - - - - - - - 203
Todd & Crittenden's mines, south fork Kentucky river, section at, - 215
Topographical Geological report, - - - - - - - - 381
Topographical survey, method adopted in, - - - - - - 383
Tradewater river, - - - - - - - - - - - 389
Tradewater river coals, - - - - - - - - - - 125, 394
Troublesome creek, cannel coal, and salt water, - - - - - 211
Tug fork, Big Sandy, coals on, - - - - - - - - 203
Tygert's creek iron ore, - - - - - - - - - - 200
Union county, geology of, - - - - - - - - - 392
Union county, detailed survey of, remarks on, - - - - - - 106
Upper coal measures, order of superposition, - - - - - - 40, 42
Vegetables, mineral elements of, - - - - - - - - 375
War gap, Pine mountain, - - - - - - - - - 226
Water, supposed to cause milk sickness, - - - - - - - 159
W[illegible]'s creek coal, - - - - - - - - - - 240
Whitesburg, salt borings, - - - - - - - - - 229
Williams's landing, Green River, section at, - - - - - - 143
Williams's landing, iron ore at, - - - - - - - - 60
Wolf hill coal, Daviess county, (No. 131,) analysis of, - - - 44, 154
York bed of coal, Three-mile creek, - - - - - - - 203
Zinc ore, Crittenden county, analysis of, - - - - - - 276



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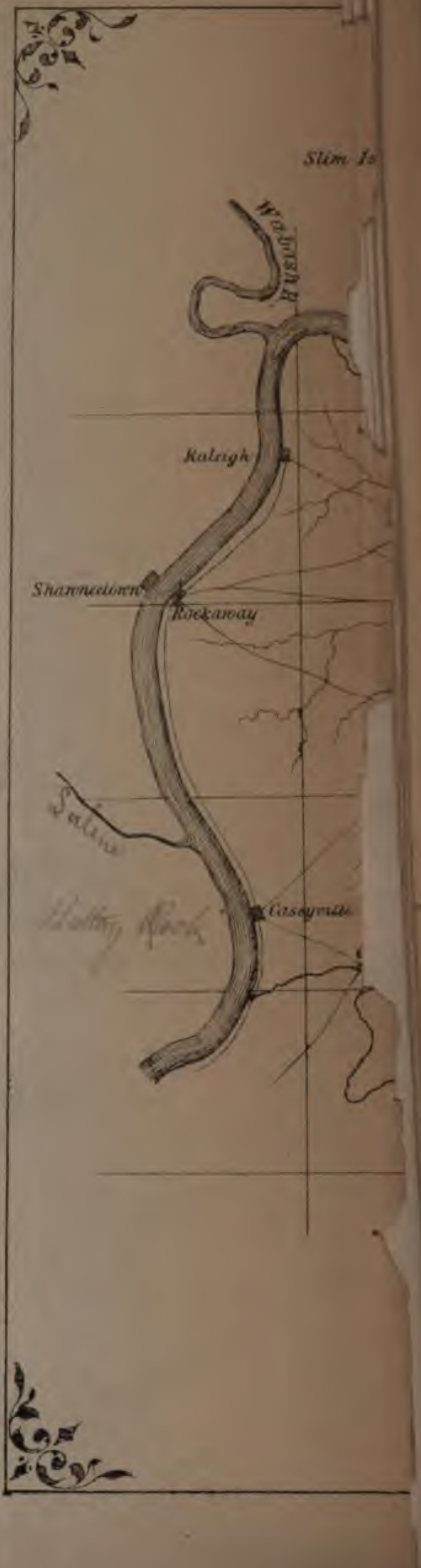
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